THE TIMBERING OF METALLIFEROUS MINES.

THE TIMBERING OF METALLIFEROUS MINES.

BY

J. F. DOWNEY, M.Inst.Min. and Met.,

INSPECTOR OF MINES, NEW ZEALAND GOVERNMENT.

With 327 Illustrations.

LONDON:

CHARLES GRIFFIN & COMPANY, LIMITED,

42 DRURY LANE, W.C. 2.

1928.

Printed in Great Britain by
NEILL & Co., LTD., EDINBURGH.

FOREWORD.

It has been my privilege to read Mr. Downey's book in manuscript, and I have found that it embodies, in great part, the results of his own wide experience and observation. Wisely, I think, he has not failed to make use of the store of information scattered throughout the world's leading mining and engineering journals.

The dominant note of mining is the extracting of minerals at the minimum cost consistent with the maximum safety of the miners. The underground workings of the ancients were relatively shallow, for the reason that the zone of safety was limited by the moderate depth to which the miners could be protected from danger or sudden death. By the proper use of timber supports and the adoption of improved hoisting gear the safety zone has been extended almost tenfold within the memory of living man.

Books devoted to mine-timbering are rare, this in part arising from the fact that the men possessing the requisite practical experience are, as a rule, without literary skill. Mr. Downey possesses both the knowledge and literary skill, together with painstaking industry. The result is a book that I am sure will be a welcome addition to the literature of practical mining.

JAMES PARK.

Otago University, Dunedin, N.Z.,
June 1928.

PREFACE.

On many occasions during years of experience as mine-manager and Inspector of Mines it has been strongly impressed on the writer that a real need exists amongst a large body of men engaged in practical mining for a compact and reasonably comprehensive handbook dealing with the timbering of metalliferous mines.

Much has been published in past years on the subject, but it has, for the most part, consisted of books treating only certain phases of the work, or else of short papers scattered through many journals or bulletins devoted to mining interests and not readily accessible to the ordinary reader. In collating, therefore, all the more valuable portions of this information in a systematic form, in filling up as far as possible the gaps left by previous writers, and by supplementing the whole by much practical knowledge acquired through nearly a lifetime of active mining work, the author has provided such a volume as seemed to him to be required, and thereby hopes to render a useful service to the mining public.

In drawing upon matter previously published, due acknowledgment has been made in each case to the writer whose work has been made use of, or to the mining publication in which it appeared.

It may be that the whole ground traversed by the subject has not been covered by the text and illustrations, but an effort has been made to describe at least all those methods of mine-timbering of which a knowledge is most essential to the class of reader whose requirements the book is designed to meet.

J. F. D.

Reefton, New Zealand,
June 1928.

CONTENTS.

THE TIMBERING OF METALLIFEROUS MINES.

CHAPTER I.

VERTICAL SHAFTS.

In metal mining the various kinds of shafts employed may be grouped under four general types, the rectangular vertical, the rectangular inclined, the rectangular combined (partly vertical, partly inclined), and the vertical cylindrical. The latter is seldom carried down entirely with timber support, consequently it will not be dealt with at any length in these pages. Of the other types, the particular form to be adopted is determined mainly by the dip of the lode it is intended to exploit from it.

Of all shaft types, the rectangular vertical is the most commonly used, for the simple reason that it is the most suitable for the mining of the general run of metalliferous deposits.

In forming this type of shaft there is much variation in the methods followed—the shape, size, and number of compartments depending on the amount of service required. Fig. 1 will serve to show some of the many designs to which it lends itself. It will be seen that for inclined shafts such designs as A or E would not be suitable. Even for vertical shafts, these double-width forms have not been adopted very widely. As far as Australasian mining fields are concerned, this type of shaft has been ruled out altogether, but some very deep shafts of the kind have been put down in the United States of America and elsewhere.

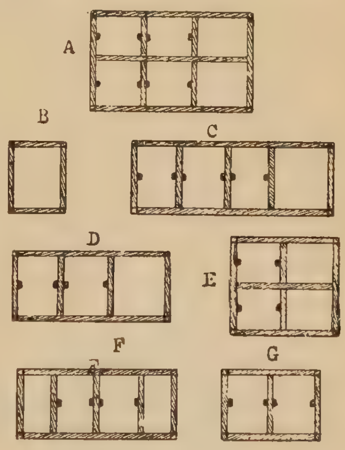


FIG. 1.—Shaft designs.

For prospecting purposes, the small single-compartment vertical shaft was used in former years to a considerable extent, but is now rarely seen, and was at no time to be commended. The necessity of ensuring good natural ventilation, and of having a ladder-way closed off from the hauling compartment, has led to a general recognition of the fact that, however primitive a shaft may be, at least two compartments are essential.

Practically all prospecting shafts are now made with two compartments, which may be as small or as large as the occasion demands. Such shafts are, as a rule, only meant to serve a temporary purpose, consequently they are seldom of a size greater than that actually needed to permit the sinkers to work to advantage. If it happens that all the rock broken in sinking has to be

hauled by means of a hand-windlass, the tendency is to keep the dimensions down to 6 feet by 2 feet 6 inches in the clear, but where power is available the measurements of the opening may be up to 8 feet by 4 feet. For prospecting work, or down to depths, say not exceeding 150 feet, small shafts may serve their purpose well, but under all other circumstances a shaft with at least three compartments, two of which are used as haulage-ways and the other as a ladder-way, is to be preferred. The ladder-way also carries the air and water pipes, pumping column, electric cables, etc.

It is only in mines with a large output that shafts with a greater number of compartments are required. Throughout Western Australia, Cleland (1)[1] mentions that in all instances the shafts are divided into three compartments, though in a few isolated cases the ladder-way has been subdivided to form an auxiliary hoisting-way. In these three-compartment shafts, the ladder-way is sometimes of smaller size than the haulage-ways, but the general practice is to have it larger than them.

Just as there is no standard design for rectangular shafts, so there is no generally accepted size for the compartments, and the same thing may be said with regard to the dimensions of the timber used. The sectional area of the opening is determined by the extent and nature of the deposit to be worked, the class of ground in which the shaft is to be sunk, and other local considerations. The size of timber to be used will depend on the kind available, the character of the rock to be penetrated, the pressure likely to be exerted by the shaft-walls, and the cost of the material.

In the following pages the dimensions of the timbers to be used in shafts and other mine openings are given, but only with the idea of affording general guidance. It may be said that any method of shaft-timbering described here may be adapted to any size of shaft or to timber of any dimensions.

Whatever the size of a vertical shaft, or whatever may be its internal arrangement, the methods of placing the timbers may all be described as belonging to one or other of the two systems known as *boxing* and *frame-setting*.

THE BOXING SYSTEM.

In the boxing system, as the name implies, successive sets of timber are placed in contact one above the other as in fig. 2, or they are slightly separated as in figs. 3 and 4. Each set comprises two side- and two end-plates; and the compartments are formed by dividers. In spaced sets the planks are kept apart by small wooden blocks at the corners and opposite the dividers. This is commonly known as the loose-chock method.

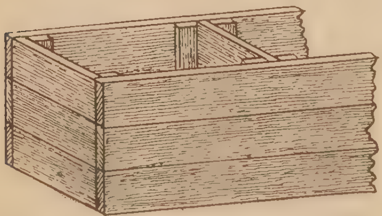


FIG. 2.—Sets for small boxed shaft.

In the method illustrated in fig. 4 the separation of the sets is effected by cutting either the end- or side-plates, preferably the former, in such a way that when the timbers are in place each successive set is raised from 2 inches to 4 inches from the one beneath it. This is known as the solid-chock method.

In fig. 4 it will be noted that the side-plates are checked to a sufficient depth to provide a shoulder against which the end-plate rests: this is to prevent the latter being forced into the shaft.

[1] The figures in brackets refer to Bibliography.

The boxing method shown in fig. 2 is not now adopted to any great extent. Ground that does not swell or flake seriously does not need such close timbering, and if, on the other hand, it is of a swelling nature, the timber is only too likely to be burst unless some space is left through which the pressure may either ease itself or be eased by the workmen. The adoption of this method also entails the use of a much greater amount of timber than would be necessary when spaces are allowed between the sets, hence it is not as economical as the other.

In some mining districts it has been found so necessary to have spaces left to admit of the removal of swelling ground from about the shafts that small square-sets, known as *jacket* or *easer* sets, lined with open lagging, have had to be put in all around the shaft-frames proper, gangs of men being employed doing little else than picking the ground out to relieve the tremendous strain that is thrown on the sets. In certain circumstances spacing, instead of being helpful may be harmful. At the No. 2 shaft of the Butte and Superior Mine

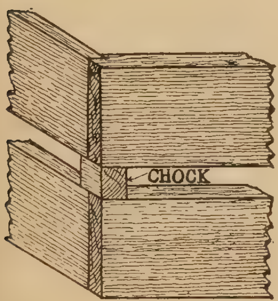


FIG. 3.—Loose-chock method of spacing box-sets.

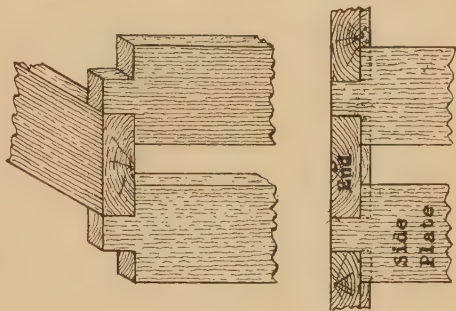


FIG. 4.—Solid-chock method of spacing box-sets.

at Montana, U.S.A., Parsons (2) states that, prior to 1917, the standard timbering consisted of frame-sets of 12-inch by 12-inch timber, with dividers of 12 inches by 8 inches, spaced with 4-foot to 5-foot centres, and lagged with 2-inch to 3-inch plank, but the cost of maintenance was found so heavy that means of reducing it had to be sought. One effort made in this direction was to timber 450 feet of the shaft, a three-compartment one, with close cribbing of 12-inch by 12-inch timbers, laid skin to skin to form a solid casing, with the necessary dividers between compartments, and it was found that when each ring had been thoroughly blocked against the walls there was practically no chance for local movement of the rock, and that the collective strength of the structure was sufficient to withstand the unusual pressures. It may be said, however, that only under exceptional circumstances is such close timbering necessary or justifiable.

Timbering Small Prospecting Shafts.

For the small one-compartment or two-compartment shafts used in prospecting, the box-sets are usually of very simple character. When round timber of a suitable kind is procurable it is commonly employed, and the methods of cutting it in most general use are those shown in fig. 5. Method A consists in merely cutting shallow joggles at the top and bottom of each plate near their ends, the under joggle of the upper piece of timber resting in that cut in the top of the piece beneath. Method B allows the cutting of checks

in the side-plates only. In method D, checks are provided in both end- and side-plate. Probably the most popular way of preparing the sets is that

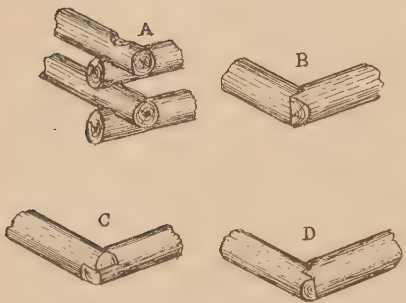


FIG. 5.—Round timber sets for small shafts.

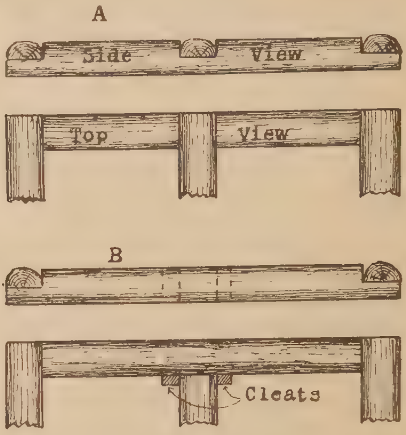


FIG. 6.—Round timber sets for two-compartment shaft.

shown at C, the joints at the corners being made by simply halving the timbers.

When it is desired to close off part of a small shaft as a ladder-way, the dividers are usually secured in one or other of the ways shown at A and B (fig. 6). In the first of these a housing is cut in the side-plate into which the

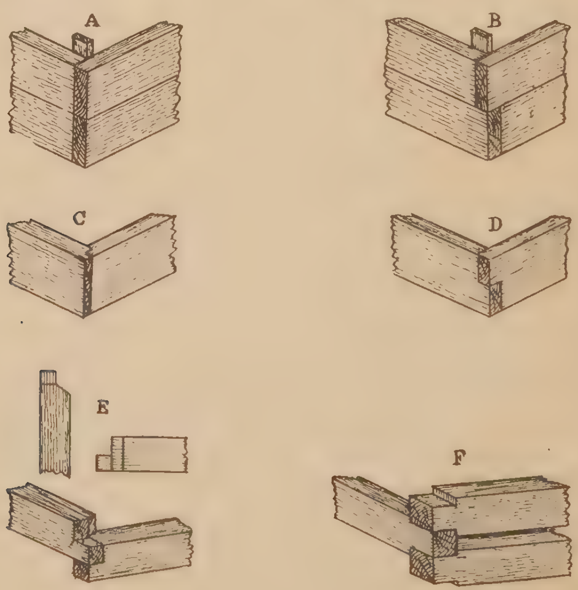


FIG. 7.—Sawn timber sets for small shafts.

halved end of the divider fits. In the other, the dividers are merely held in place by having vertical cleats nailed on either side of them. If the partition

needs to be close timbered, as for ventilation purposes, the latter method is the best, for with a little trimming the dividers can be made to slip down between the cleats so as to sit tightly on one another.

When sawn timber is used, a greater variety of methods of preparing the sets may be followed. Fig. 7 shows some of them. Sets A, B, C, and D are examples of close boxing, no spaces being left between the timbers, but, with any of these, spaces may be provided by using loose chocks. As a rule, the timber employed in making these sets is of light character, 8 inches by $1\frac{1}{2}$ inch, or 8 inches by 2 inches, and the plates are placed on edge.

As shafts of the kind referred to are seldom more than 6 feet by 3 feet in the clear, timbers of these dimensions are usually strong enough to meet all requirements.

Sets A and B are extremely simple, the various members being cut square at the ends, and merely held in place by the cleats or battens nailed vertically in the shaft corners.

Sets D and E are constructed on the halving principle, both the side- and end-plates being provided with shoulders.

Methods C, E, and F represent sets suitable for the largest size of two-compartment shaft, even when a fair amount of pressure from the rock may be expected. In the two latter, somewhat heavier timber is used than in the other, and in method E the joint is made with a bevelled check so that the full strength of the timber is retained. Method F represents a solid-chock set, the members being cut in such a way as to provide spaces between the sets.

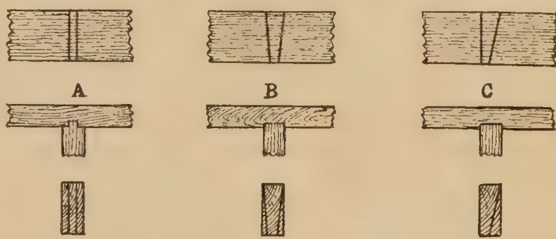


Fig. 8.—Methods of securing dividers.

To form compartments, centres or dividers are either placed as at B (fig. 6), the pieces of timber being cut off square at the ends and held in place by cleats, or tenons are cut at each end of the divider so as to fit into slots in the wall-plates. These slots may be made by running two shallow parallel saw-cuts, as at A (fig. 8), and chiselling out the timber between them, or by giving the cuts a bevel on one or both sides, the tenon of the divider being shaped to suit.

When a shaft is being closely boxed, any of these methods of securing the dividers may be employed, but it is obvious that if spaces are to be left between the sets, and the partitioning is, in accordance with the usual practice, to be close fitting, the bevelled tenon and mortice cannot be used. The straight-sided tenon and slot shown at A must be used, as the dividers will then slide down one on another. It is not unusual, even when the dividers are secured in the way described, for cleats also to be nailed on either side of them, but if the sets are properly wedged and packed the latter should not be needed.

Three-Compartment Box Shafts.

In the timbering of the larger class of shafts, heavier timbers are required. If good hard wood is available, plates of 8 inches by 3 inches in cross-section may be strong enough, but if inferior timber is used it should be of from 8 inches by 4 inches to 8 inches by 6 inches in cross-section. Practically the same methods of cutting and placing the sets are followed as in the case of the smaller

shaft. Fig. 9 shows a number of frame-sets in actual use. It will be seen that

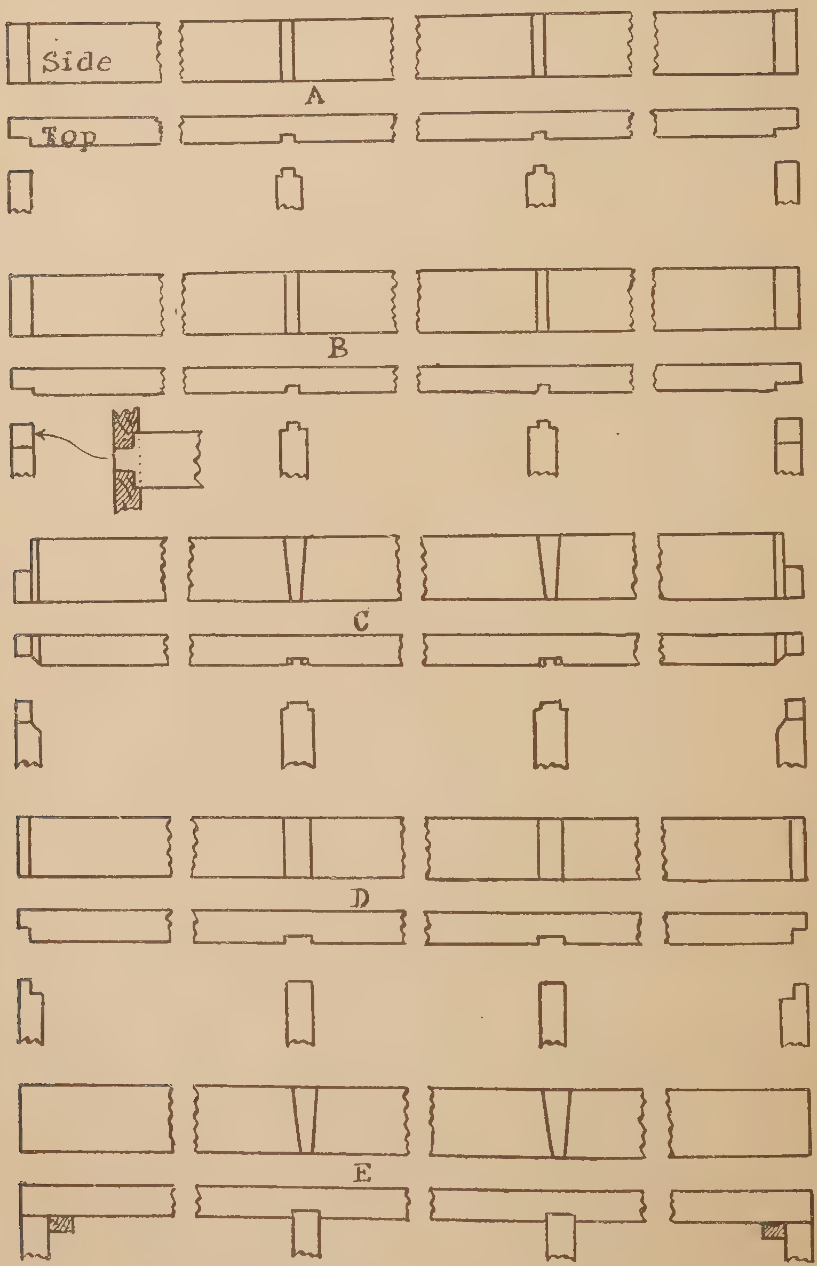


FIG. 9.—Box-sets.

they are for the most part merely adaptations of the methods already described. Of all the sets, that shown at E is the least to be recommended, as no check

or shoulder is provided at the corners. In an important shaft, especially if the walls are not of a good standing nature, this kind of set is best avoided. The cutting of it has the advantage of enabling the set to be cheaply prepared, but its adoption is liable to lead to serious loss and inconvenience later on. In one shaft known to the writer in which it was used the ends for hundreds of feet were forced gradually out of alignment, with the result that the whole run of timber had to be replaced.

Of the other sets illustrated, that shown at C is probably the most generally favoured. The joint is made by halving both end- and wall-plates, and, to make the set additionally strong, bevels are provided so that the full section of timber in each plate is offered to any pressure exerted by the walls.

In some shafts, particularly when the timber available is not of good quality, the practice is to use timber of fairly small section, say 8 inches by 3 inches, or 8 inches by 4 inches, and to put in at short intervals sets of heavier material, say 8 inches by 6 inches. This plan at times gives good results.

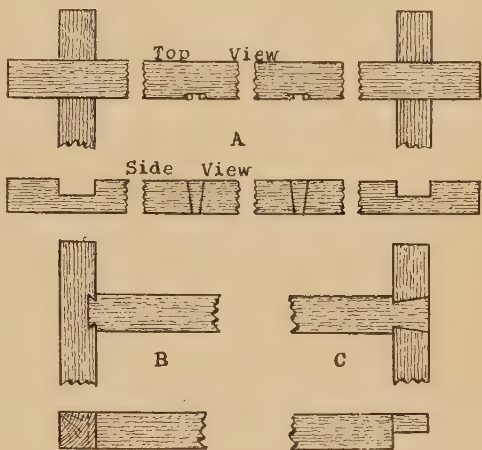


Fig. 10.—Collar-sets for boxed shaft.

Collar- or Brace-Set.—When starting to timber from the surface a box shaft that is to be used for main haulage purposes, the first work to be done is the placing in position of what is known as the *collar-* or *brace*-set. This set forms the topmost or collar-set; and as the entire shaft takes its alignment from it, the greatest care must be taken to see that it is cut true and put in place both level and square; and as it usually supports part of the super-structure forming the poppet-head, it is necessary it should be made of timber of the best quality procurable and of reasonably large sectional area. Material 12 inches by 12 inches is about the smallest used.

Collar-sets are prepared in various ways, of which the most generally adopted are A and B (fig. 10). In the first of these it will be seen that the joint is made by halving the timber, and that long horns are left on both the side- and end-plate. The leaving of these horns is advisable, especially when the brace stands, as it often does, on loose ground. The horns in such cases give the set greater supporting strength than it would otherwise have, and at the same time prevent it from sinking.

In method B the horns are left on the side-plates only, the ends of the shorter plates being provided with dovetail tenons which fit into mortices of the same shape in the side-plates. In method C the horns are dispensed with altogether, the joint being made by halving the timber, the scarf and housing on the end- and side-plates respectively being cut so as to dovetail, the object being to prevent the set from spreading. With all these sets, slots are cut in the usual way to hold dividers in place. In the case of frame-set shafts, other ways of preparing the sets are followed, but these will be referred to later.

When the shaft is very long, it may not be convenient at all times to use side-plates all in one piece for the sets, but it is best to do so in all cases if

it is at all possible. If splicing is necessary, the joint is usually made as shown in fig. 11, the two pieces of timber being bolted together by $\frac{1}{4}$-inch iron plates placed top and bottom.

Placing Box-Sets in Position.—It often happens that it is not possible to carry a shaft down to any considerable depth before it is necessary to timber. In the mines of the West Coast of New Zealand, for instance, the nature of the wall-rocks will rarely permit more than 5 feet or 6 feet of ground being opened without support; and in many cases it is actually compulsory, in order to prevent caving, to put in each set of timber as soon as room is made for it. When the latter condition prevails, all that can be done is to secure each set independently, by wedging and blocking, as well as the circumstances will allow. It is rather unfortunate both for the mine and those in charge of it when shaft timber has to be rushed into place in this way, for it is practically impossible to wedge and pack the sets in a thoroughly satisfactory manner, with the result that, sooner or later, they are thrust out of alignment, necessitating much labour and expense in putting them back in place. If but a moderate depth of say 5 feet or 6 feet can be opened at a time in safety, the position is not so bad, for a pair of bearers can then be hitched across the ends of the shaft near the bottom, and the sets built up on them, thereby giving the opportunity to wedge and pack the timber solidly.

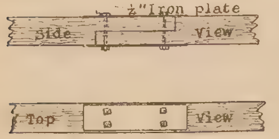


Fig. 11.—Splicing side-plates in collar-sets.

Bearer-Sets in Box Shafts.—When a shaft is to be sunk in good standing ground, it is customary, before putting in a run of boxing, to carry the sinking down as far as safety will permit. Under favourable conditions this may be for as much as 30 feet to 40 feet. The object in doing this is to save the timber as much as possible from damage from blasting operations, and partly to save time, for it may be readily understood that the oftener the men have to stop sinking to place timber the greater is the extent to which progress in excavating is retarded.

The fact that much better opportunity is afforded of securing the sets rigidly in position by starting well below the standing timber, and building up to it, is another good reason for the adoption of this plan.

When this method of working can be followed, the almost invariable practice is to first put in what is known as a bearer-set. This may consist merely of a pair of stout beams placed across the shaft in alignment with the collar-set or the timber next above, with their ends hitched securely into the walls, or it may be a ring of timber forming a complete set, in which case the end pieces only are hitched. When a set of this kind is used, it is commonly framed as shown in fig. 12. The timber used is of larger size than that from which the regular box-sets are made. The timber is weakened as little as possible by cutting in making the corner joints. The main purpose of the set being to support the others superimposed on it, any method of preparing that entails much cutting away of any member of it to make the joint robs it of its greatest value.

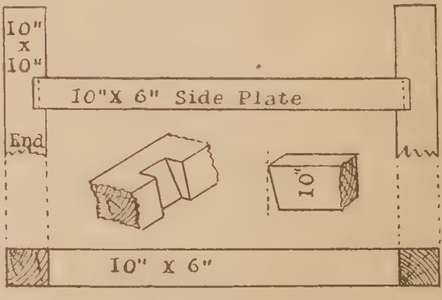


Fig. 12.—Bearer-set for boxed shaft.

Aligning Box-Sets.—Care is taken to see that bearer-sets are level and

in perfect line with the timber previously put in, and also that they are rigid, for they are often used as permanent stations from which the alignment of subsequent timbering is effected. They are themselves aligned by means of plumb-lines hung from the station next above. These lines, which have heavy weights (bobs) attached to them, are hung at or near the shaft corners, and are kept in place during the whole time it takes to put the new section of timber in. It is not customary to hang them directly in the corners, but from a small cleat of square section nailed in the corner, as at A (fig. 13). The timbermen are provided with similar cleats to use as gauges, and by holding these in the corners of the set they can readily tell whether it is in place or not.

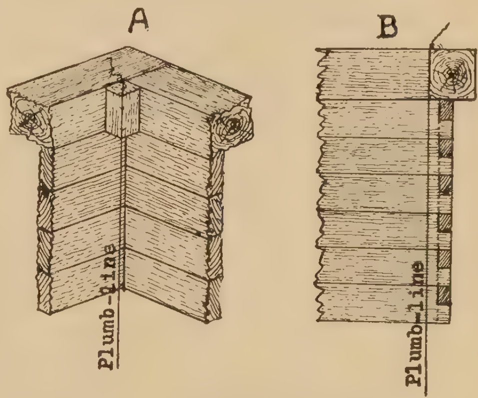


FIG. 13.—Hanging plumb-lines.

Instead of suspending the line from a cleat, the practice is sometimes followed of placing the collar-, plat-, or bearer-sets in such a way that their plates intrude about 2 inches all round into the shaft beyond the ordinary boxing, and hanging it from the corners of these sets which then serve as permanent stations for alignment purposes.

Wedging and Packing Box-Sets.—The proper blocking and wedging of box-sets is most necessary, but it is an operation frequently not given the care it should receive, either from the mine officials or the workmen. When the work is carried out by gangs of men kept specially for timbering, there is little fear of unskilled workmanship; but it more often happens that the work is done by the sinkers, who take the whole job on contract, and their desire to make rapid progress leads them to slum it. Strict supervision is necessary to prevent this. When shaft timber gets out of alignment, either through being thrust inward or falling back into spaces that have been left behind it or have been insufficiently packed, much inconvenience and expense are caused, and there are few mining men of experience who cannot recall instances when such things have happened. In nearly all cases the trouble can be traced to indifferent workmanship, or the adoption of improper methods of securing the sets. It cannot be too strongly urged that in this particular operation no careless work should be tolerated.

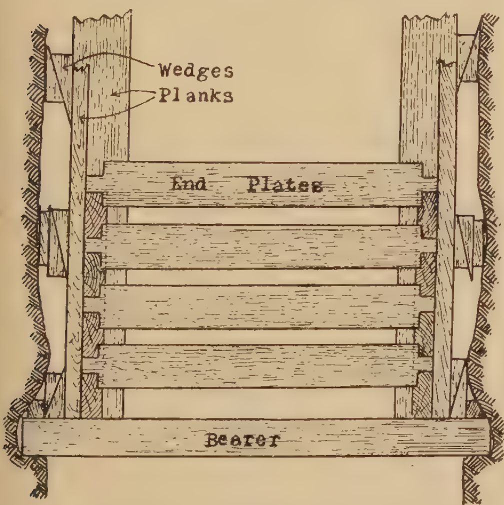


FIG. 14.—Blocking and wedging sets in boxed shaft.

The best way of blocking and wedging box-sets is shown in fig. 14. Two or three sets of timber are put approximately in place above the bearer-set, then planks of timber of suitable size, say 6 inches by 2 inches or 6 inches by 3 inches, are placed upright outside the end- and wall-plates at each corner, and also opposite each divider. Between the planks and the rock, blocks of any suitable size are inserted, with trimmed wedges between them and the uprights. The wedges at the corners are usually driven sufficiently tight to hold before the dividers are put in. The latter are then placed in their slots, and the blocking outside of them completed, after which the whole system of wedging is gone round again and given a final tightening, care being taken during the operation to ensure that the correct alignment of the sets is maintained.

At least two workmen should be engaged at the task, one attending to each end of the shaft. A plentiful supply of wedges sawn to shape should be available. If the timbermen on the job have to trim wedges for themselves it will be readily understood they are not so likely to do good work as if supplied with wedges already prepared; moreover, it is much cheaper to cut wedges on a saw-bench than with a hatchet.

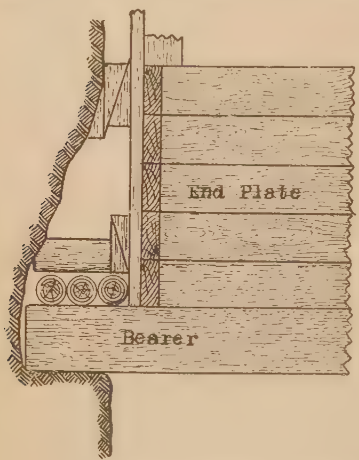


FIG. 15.—Method of securing packing.

When the wedges have all been tightened up, any space between the sets and the walls is filled with suitable packing. In some mines waste timber is used for this purpose, but this practice is to be strongly deprecated, for when the timber decays empty spaces are left. The best packing is broken rock of not too large size. Except when close timbering is adopted fine mullock should not be used, for if any spaces have been left between the sets this will fret out or be washed out by water, leaving the timber with no other support than the wedges and blocks, which themselves will often become loose owing to the flaking of the country rock.

The closing-in set, that is the last to go in to join up with the bearer-set above, is the only one that may give any trouble to wedge securely, the men being prevented by lack of room from driving wedges behind it. With a little care, however, in setting the wedging before the set is put in place it can be made almost as tight as the rest.

If, when starting a section of this class of timbering, a large opening exists between the timber and the walls, it is customary to lay poles in, as shown in fig. 15, to carry the packing. Should it be inconvenient to put these in with their ends resting on the hitched bearers, holes 1 inch in diameter may be drilled in the side-plate of the bearer-set or in the bottom side-plate of the ordinary sets, through which bars of iron sufficiently long to reach the wall are driven, and on these the poles are placed.

Lowering Timber during Shaft-Timbering Operations.—The usual method of delivering the timbers down a shaft to where they are required is to send the shorter pieces, such as dividers, ends, wedges, blocks, etc., down in the sinking-bucket, and lower the wall-plates, or other long and heavy pieces, by means of a shackle such as shown in fig. 16. A hole is bored through the

length of timber near its end, through which the bolt of the shackle is passed, the latter being attached to the haulage rope. A nut is not generally used on the shackle, but the eye on one side of it is tapped and the bolt end threaded to screw through it. When very heavy timber has to be sent down, the hole for the shackle bolt is sometimes bored near its centre instead of near the end, in which case one end of the piece is lashed up to the rope. When the timber reaches the point in the shaft where it is to be used, the workmen, when the shackle is at the top end, carry the other end forward in such a way that as the rope is slowly paid out the piece drops quietly into the approximate position it is to occupy. In the other case the lashing is removed and the timber allowed to swing into a horizontal position, when it is easily steered into any required place. By making use of the lowering rope in this way, much heavy lifting can be avoided.

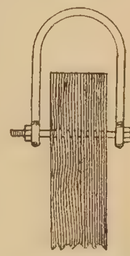


FIG. 16.—Shackle for lowering timber in shaft.

If a penthouse is not used, the timber is sometimes sent down in the cage, extension guides being used to enable the latter to be lowered to the shaft bottom.

Stages for Workmen when Timbering.—As timbering proceeds upward,

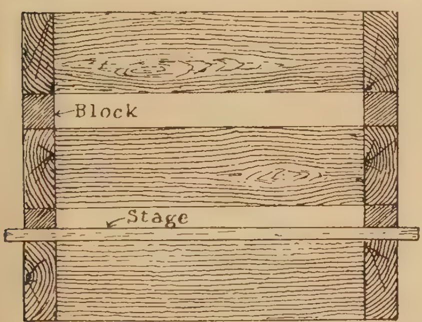


FIG. 17.—Stage for timbermen in boxed shaft.

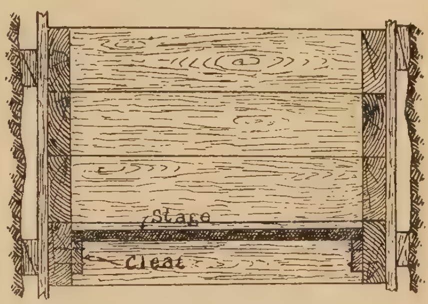


FIG. 18.—Stage for timbermen in close timber.

the men put in stages at convenient distances in at least the two end compartments. This is readily done when the sets are spaced, all that is necessary

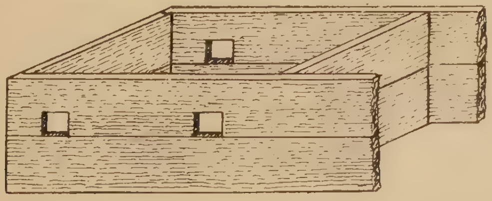


FIG. 19.—Openings cut in wall-plates for stage supports.

being to place a few stout planks across the shaft with their ends resting on the wall-plates within the spacing, as in fig. 17.

In a close-timbered shaft it is necessary, however, to make other arrangements for the stages. One plan is to nail cleats to the wall-plates, as in fig. 18, and on these to place the stage-boards, which must be cut to the exact

length. If care is exercised in securing the cleats, this method may be quite safe, but as the stage has often to carry a good deal of weight, and the safety of the men is left dependent merely on a few nails, it is not one to be recommended. To avoid resorting to it, the plan is sometimes adopted of leaving spaces between each run of five or six sets to be used for staging purposes. Another plan is to cut pieces out of the wall-plates at regular intervals, as in fig. 19, thus admitting of the insertion of bearers on which the stage-boards may be laid. This latter is an old custom now rarely followed.

Closing-in Sets.—As previously mentioned, the last sets to go in to join up with timber already in place give the most trouble to secure properly. The dividers of the last six or seven sets are left out until the whole of the side- and end-plates are in position. This is necessary to allow the long side-plates being got into place. Before putting in the last few sets of timber, the upright wedging-planks are placed at the corners and opposite the dividers, and they are so blocked from the rock walls that only sufficient room is left to force the plates into alignment. When all the sets except the last one have been put in, any spaces left between them and the walls are filled in the usual way with rock packing. The last set is then put in, after which the dividers are placed in their mortices, using a screw-jack if necessary to spread the wall-plates. If sinking is being done under a penthouse, or if the hauling of broken rock from the shaft bottom is done with a bucket, the guides are, as a rule, not put in place till the full section of the shaft has been completed, the plat or station opened out, and the penthouse removed.

VERTICAL FRAME-SETTED SHAFTS.

The frame-set, or, as it is sometimes termed, the square-set, method of shaft timbering differs from the box-set method in that heavier timber is used, and the sets are placed at greater distances apart. The interval between the sets varies with different localities, but ranges from 4 feet to about 6 feet. Lagging is placed vertically behind the sets to support the ground. The placing of the sets in position also differs in that it proceeds downward instead of upward as is usual in the other method.

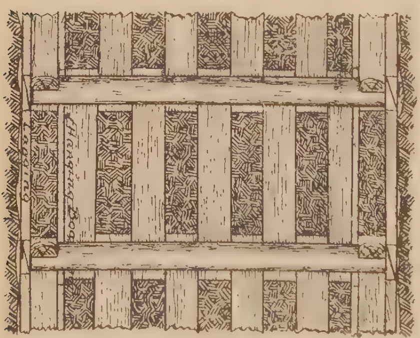


Fig. 20.—Frame-set timbering in prospecting shaft.

Frame-setting is applicable to and is employed in vertical shafts of all sizes, and is almost invariably adopted for the larger types of shaft. In a single-width rectangular shaft, the timber comprising a full frame-set consists of two side- or wall-plates, two end-plates, dividers to form the required number of compartments, posts (known also as jogs or studdles) for connecting the sets and giving them correct spacing, lagging, and cleats for the latter to rest on. The posts are placed at each corner and opposite each divider. The frames are usually hung one from another by means of iron rods used as hanging bolts.

Frame-Sets in Small Prospecting Shafts.—Where round timber is available, a modified frame-set of simple type is commonly used. This is illustrated in fig. 20, and consists of four pieces of stout sapling, halved at the

ends to make the corner joint. On the two end-pieces horns may be left which rest in hitches cut in the walls, but these are not necessary, as the set may be easily held in place by wedges and hanging-boards. Split or round lagging is

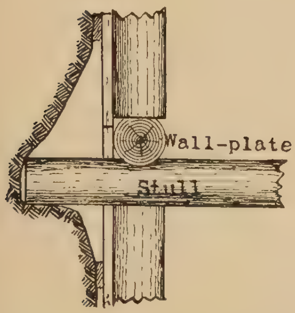


FIG. 21.—Another method of frame-setting in small shafts.

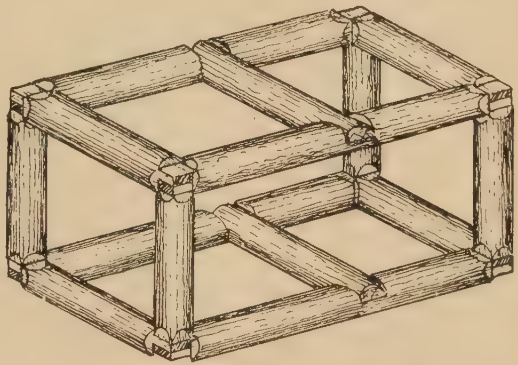


FIG. 22.—Timber for small two-compartment shaft.

placed between the sets and the ground, and if it is wedged tightly there is little danger of the timber being shifted. In country of fair standing nature this kind of timbering serves its temporary purpose well.

Another method is shown in fig. 21. In this the end-plates, which may otherwise be described as stulls, are hitched into the walls, and in them, on either side of the shaft, joggles are cut in which the wall-plates rest. On top of the latter, posts or studdles are stood at each corner, and secured by wedging or drift-nailing. This method is described by Storms (12) as being used in the Cobalt district of Ontario, but only where the walls are firm and not easily broken. If the shaft has two compartments, a third stull may be placed across as a divider under the wall-plates, but posts are only used at the corners.

Still another way of frame-setting small shafts is shown in fig. 22. In this, the joints at the corners are made by halving the timbers, the dividers being secured in place in the same way. This method of preparing a frame-set is not a good one, however, for the wall-plates are weakened too much.

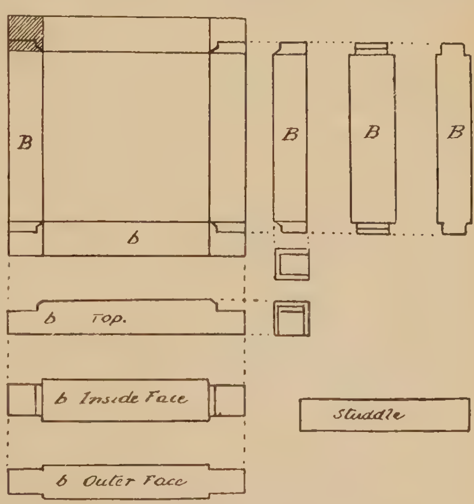


FIG. 23.—Frame-set of sawn timber for a one-compartment shaft.

When sawn timber is used, a variety of ways of making the joints offer themselves. One of them is shown in fig. 23, and is often resorted to in the construction of small one-compartment shafts which are intended to serve

subsequently the purpose of filling shafts, and consequently call for the use of somewhat heavier timber than would otherwise be necessary.

For larger and more permanent shafts, the ordinary method of preparing

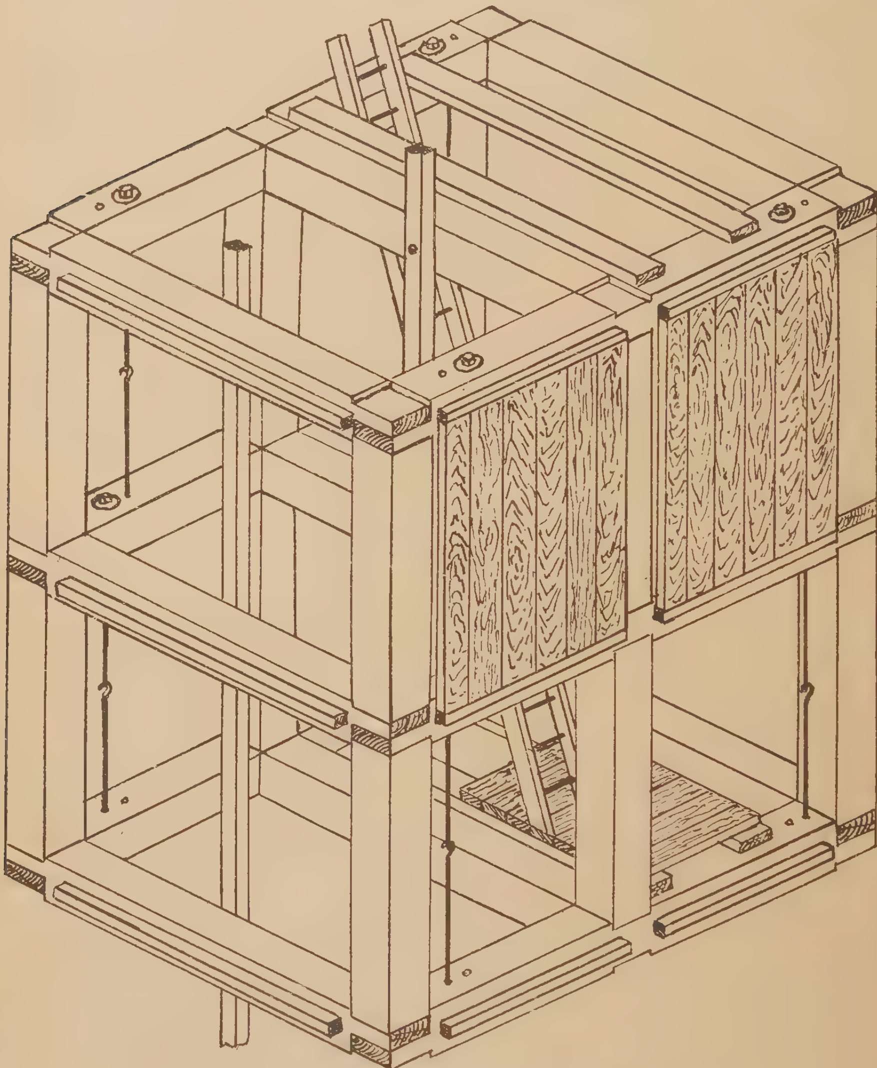


FIG. 24.—Frame-set timbering for two-compartment shaft.

and placing the timbers is shown in fig. 24. In such shafts, one compartment is used as a haulage-way, and the other as a ladder-way, the air pipes, water pipes, etc., being also carried in the latter. The two compartments are not shown completely closed off one from the other, but for safety they are frequently separated, by placing partitions of planking either vertically or horizontally between the dividers.

Three-Compartment Shafts.—For permanent working shafts, the three-compartment design is the one most generally adopted when frame-sets

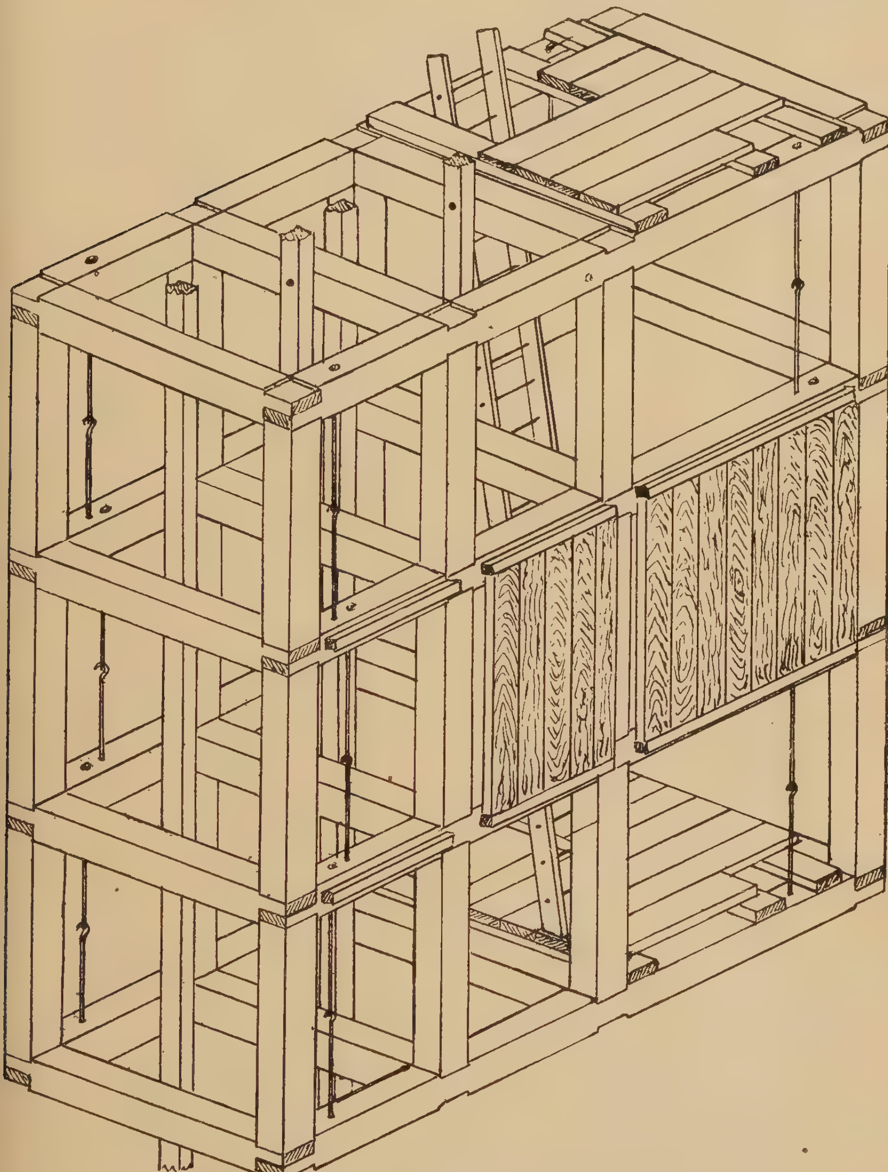


Fig. 25.—Frame-sets, three-compartment shaft.

are used, just as it is when close boxing is the favoured method of timbering. Shafts having more compartments are quite common, but they can only be economically used in special circumstances. On many mining fields the working shafts are subjected to such heavy ground-pressures that the

tendency of engineers is to restrict their size as much as possible in order to prevent excessive damage being done to the timbers; and, apart from that, the three-compartment shaft, even of moderate size, is usually found commodious enough to meet all ordinary requirements. Throughout Australia and New Zealand, shafts having a larger number of compartments are not frequently seen. A very common size for such shafts in these countries is 11 feet by 4 feet, or 11 feet by 4 feet 6 inches inside the timbers, but in places like Broken Hill, in New South Wales, where a large tonnage of ore has to be hauled, the dimensions are considerably greater. On that field the older shafts are mostly 13 feet by 6 feet, but the later ones are up to 14 feet by 11 feet in the clear. In Western Australia, where three-compartment shafts are almost invariably preferred, the earlier ones ranged from 10 feet by 4 feet inside the timber to 11 feet 8 inches by 4 feet 6 inches, while shafts of later date ranged in size from 13 feet 6 inches by 4 feet 6 inches to 14 feet by 5 feet 6 inches. On the West Coast of New Zealand the usual run of such shafts is 11 feet by 4 feet inside the timber. The size of timber used varies just as greatly. In Western Australia where local hardwoods such as salmon gum and morrel are employed, the wall- and end-plates are at times of no larger section than 9 inches by 9 inches, the dividers 9 inches by 6 inches, and the posts 8 inches by 8 inches. Where softer woods such as Oregon pine are used, the principal members of the sets are usually 12 inches by 12 inches. In the Reefton district, New Zealand, where black or brown beech is the timber mostly used, the plates are 12 inches by 12 inches, the dividers 12 inches by 8 inches, and the posts 10 inches by 10 inches. In American mining fields, 12-inch by 12-inch timbers are generally used.

As a rule, in three-compartment shafts, two compartments are used for hauling, and the third as a ladder-way, etc. The latter is invariably placed at one end of the shaft, and is usually larger than the others. Where much water has to be dealt with, and large pumping plants have consequently to be installed, it is necessary that this compartment should be of large size. The usual arrangement of such shafts is shown in fig. 25. In this illustration a portion only of the lagging and cleating is shown. For the sake of clearness, the close partitioning usual between the ladder and haulage compartments has also been left out.

The only detail in which the timbering of shafts of this description varies is in the actual preparation of the sets, that is to say, the way in which the joints are made, and even here the variations follow to a great extent the lines already indicated when dealing with the preparation of sets for smaller shafts.

Figs. 26 to 31 show some of the many ways of preparing the sets in common use.

Fig. 26 illustrates a method described by Cleland (1) as used to a considerable extent in Western Australia. The corner joint is made by halving the timbers. The cutting of mortices, as shown at top and bottom of the plates, to receive the posts is a practice not often seen elsewhere, and must add considerably to the cost of preparing the set. Those for the corner posts are 4 inches by 4 inches, and those for the other posts 6 inches by 3 inches, and all are 1 inch deep. To hold the dividers, the wall-plates are morticed also to a depth of 1 inch, tapering from 6 inches at the upper side to 3 inches at the bottom.

The method shown in fig. 27 is a very simple one, the timbers being halved to make the corner joint, and no mortices or daps of any kind being cut for the posts, the latter being secured in place by drift-nailing. From the point

of view of economy in preparation, this frame-set commends itself, and in firm ground sets of this kind should give good service, but where any pressure

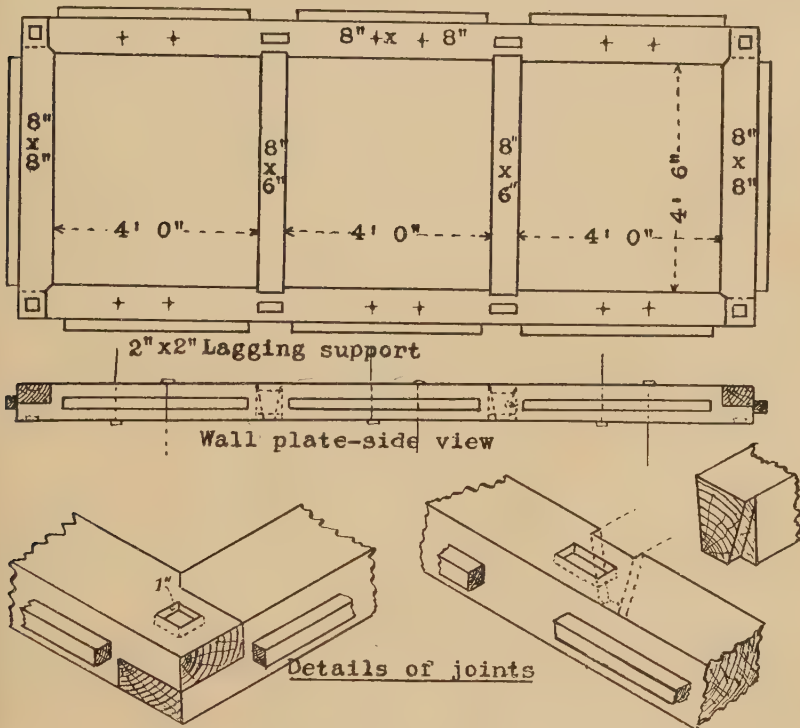


FIG. 26.—Details of frame-set, three-compartment shaft.

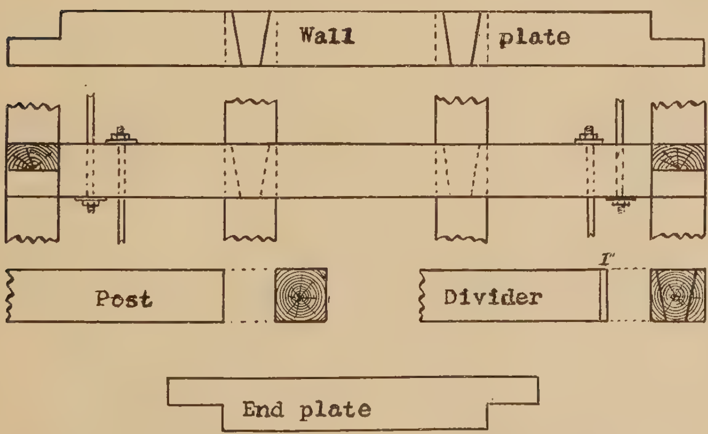


FIG. 27.—Details of frame-set, three-compartment shaft.

s exerted on the timber by the surrounding country the lack of daps for the posts renders these likely to be thrust into the shaft, and thus cause a good deal of trouble.

Fig. 28 shows a method described by Storms (12) as being used in California, and generally in the Western mining districts of U.S.A. In other parts of the world it is not adopted for vertical-shaft timbering to any extent. It is an adaptation of an old method followed in inclined shafts. The features

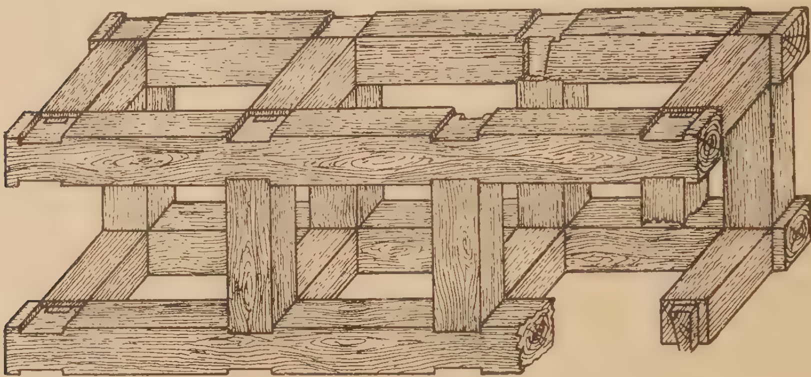


FIG. 28.—Details of frame-set, three-compartment shaft.

that differentiate it most strikingly from the frame-sets in most common use are that the end-plates do not overlap the wall-plates in any way, and the extent to which the full strength of the timber is conserved. The ends are prepared and secured in place in exactly the same way as the dividers—that

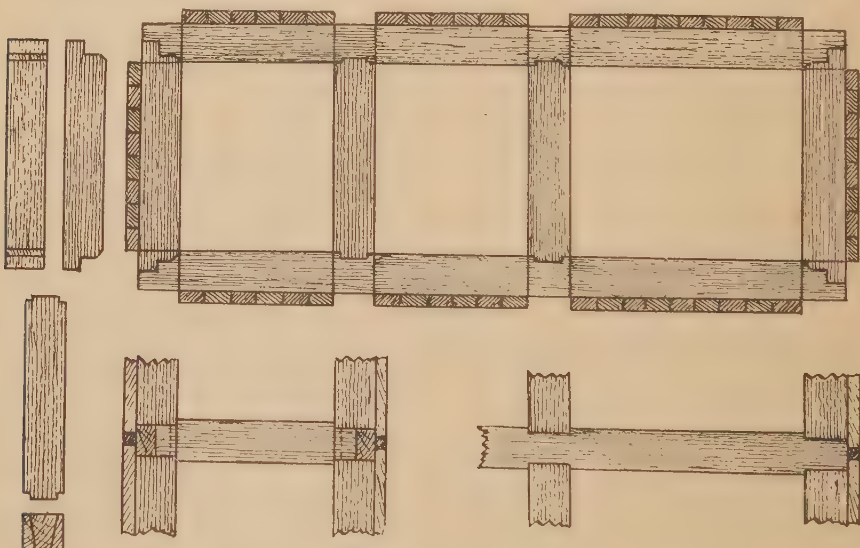


FIG. 29.—Details of frame-set, three-compartment shaft.

is to say, they are provided with dovetail tenons which enter mortices cut to the same shape in the wall-plates. Shallow daps, the size of the full section of the posts, are cut to receive the latter. In ground that does not shift by reason of unequal pressure or changing direction, this framing is said to have fulfilled every requirement.

Fig. 29 illustrates a method used in the Nevada district, U.S.A., and at one time rather popular there. In this set the end-plates do not rest upon the wall-plates, but butt against them. Storms (12) mentions that "the idea of this design was to minimise the tendency of the timber to split under heavy

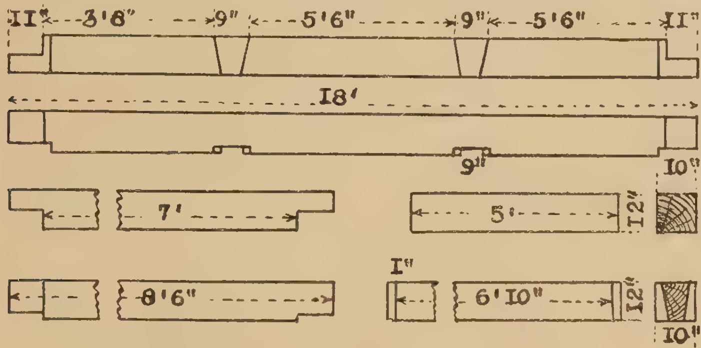
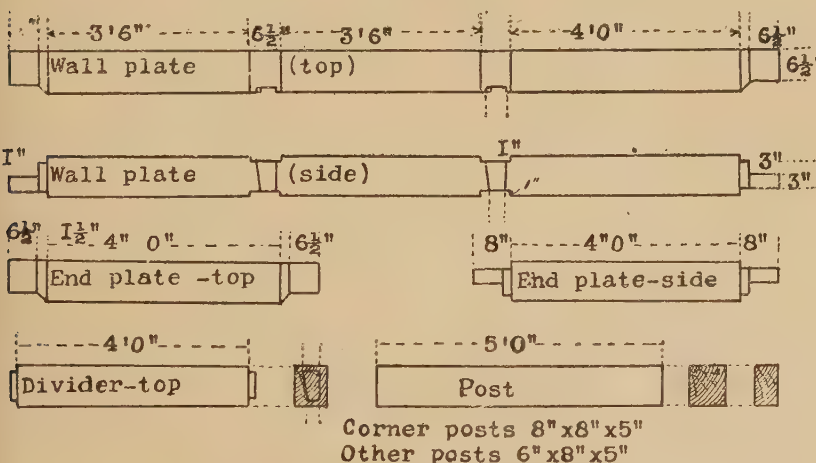


Fig. 30.—Details of frame-set, three-compartment shaft.

pressure from the surrounding country," and that the attainment of this object "was still further promoted by cutting a bevel at the inside corner of both end- and wall-plates."

Fig. 30 shows a frame-set described by Rice (55) as used in the solid ground



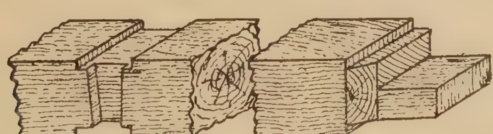


Fig. 31.—Details of frame-set, three-compartment shaft.

at the Indiana Mine, Michigan, U.S.A., while fig. 31 illustrates a set very commonly adopted in the Australian States and New Zealand.

It will be noted that in several of the methods the bevel cut in the corner joint appears. As a matter of fact the use of this bevel has now become

widespread in the mining world, but it has been questioned if it is as effective as seems to be generally believed. Referring to it, Storms (12) remarks: "The practice of framing timbers in this manner originated on the Comstock, Nevada, the idea being that the bevel minimised the tendency of the timbers to split when exposed to heavy pressure; but it is our experience that when the rocks through which a shaft is sunk swell, or from any other cause exert unusual pressure on the timber-sets, the tendency of the timbers to split and crush is not materially decreased by the bevel at the inside corners of the set." A great deal of care is necessary in cutting these bevels, and the use of them adds to the cost of preparing the sets. In preparing such heavy timbers as are usually employed in frame-set shafts, it is probable that the bevel could be dispensed with without danger in many cases, especially when only moderate pressures may be expected from the walls, but it is advisable to use it with the lighter timbers employed in boxed shafts. In the Reefton district of New Zealand, where considerable

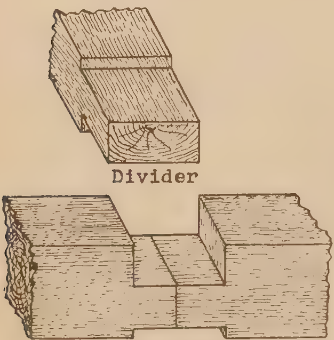


Fig. 32.—Splicing wall-plates in frame-set shaft.

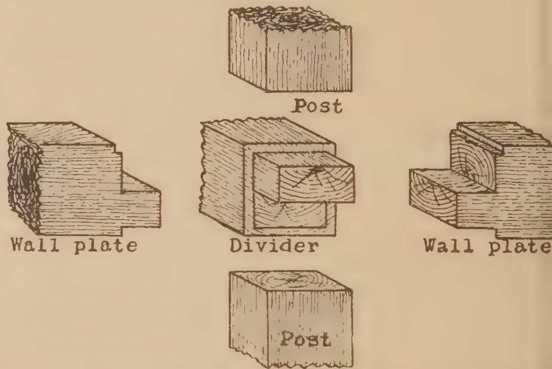


Fig. 33.—Another method of splicing wall-plates in frame-set shaft.

pressure is exerted by the country, it has become almost the invariable rule to use it in such cases.

Single Width Shafts of more than Three Compartments.—Any of the methods of preparing frame-sets already described are applicable to these larger shafts. It is merely a matter of providing longer wall-plates. No detailed description of timbering them need therefore be given here.

Spliced Wall-Plates.—When very long shafts are being timbered, it is sometimes necessary to have the wall-plates in two pieces. If it is at all possible, it is, of course, advisable that shaft wall-plates should be whole, for a splay or joint in them, no matter how well made, is a source of weakness. At times, however, it is difficult to get timbers sufficiently long for the purpose, and at others the inconvenience, and even impossibility, of handling very long timbers under-ground necessitate the plates being made in two pieces. It may be readily understood that in a long shaft that is being sunk in heavy ground, where the timbering has to be kept well down to the bottom, plates of great length would be very difficult to get into place. When splicing is necessary, the method of making the joint is as shown in figs. 32 and 33. For obvious reasons the splice is invariably placed opposite the end of one of the shaft partitions, and as near as circumstances permit to the centre line of the full length of the

wall-plate. If the shaft has three compartments, the joint is made at the partition between the ladder-way and the haulage-ways. It will be noted that the divider at the splice is prepared differently from the usual practice, ends being left on it to overlap those of the sections of wall-plate. A dap is cut in the divider to receive the post.

Double-Width Shafts.—In metalliferous mining the double-width shaft has not been widely adopted, and few examples of it are seen outside North America. One reason for this is that it has generally been found easier to sink and timber a long shaft one compartment wide than a shorter one having the width of two compartments, and another is that extremely large shafts of this latter type are seldom required in metal mining. Still another reason may be found in the fact that in metal mining shaft-sinking in many cases has in it an element of prospecting, and there seems no great call for putting down very large and costly openings until definite proof is at hand that such a course is justified. Nevertheless, quite a number of shafts of this kind have been constructed, some of which are among the deepest in the world, and under certain circumstances they may be more suitable for the work required of them than the ordinary narrow shaft. Nearly all shafts are sunk with their long axis parallel to the strike of the lode they are intended to exploit, consequently the greatest pressures they are called upon to resist are side pressures, or, in other words, pressures exerted at right angles to the direction in which the mine workings extend. The more ground that is open along the strike of the lode, the more the pressure on the shaft is liable to be. If the latter is sunk close to, or in the lode, this pressure may be considerable. The fact, therefore, that in sinking a double-width shaft less ground need be opened along the line of the lode may be a point in favour of adopting this type. The great length of the cross-members of the sets, especially of the end-plates, and the multiplicity of joints in each individual set somewhat offset any advantage offered by the shorter length of the shaft, but if the wedging and packing of the timber is well attended to, weaknesses from these causes may be largely eliminated.

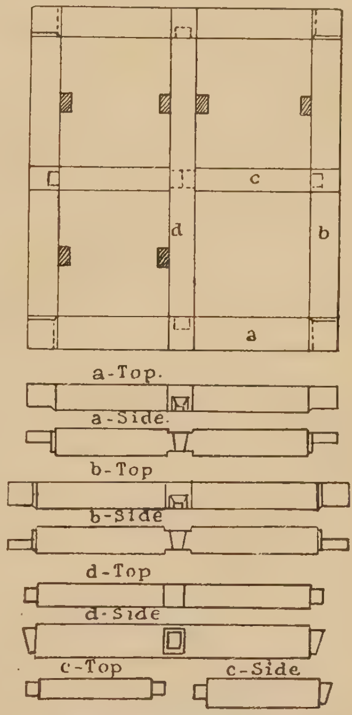


Fig. 34.—Frame-set for four-compartment, double-width shaft.

The usual way of framing the timbers for a four-compartment double-width shaft is shown with sufficient clearness in fig. 34, but almost all the methods of framing already described when dealing with single-width shafts are adaptable to it. Thus, instead of halving the timbers to make the corner joints, the end-plates may be secured in the manner shown in fig. 28. It will be seen that in fig. 34 the ends and sides, as well as the main central divider, are in one piece. The direction in which this divider is placed is not material, but it is advisable to set it across

the shaft, that is, against, or at a right angle to, the strike of the surrounding country. The short dividers effectively stay and strengthen the other members of the set.

The largest double-width shaft so far put down has not contained more than six compartments, but as the provision of the extra two compartments

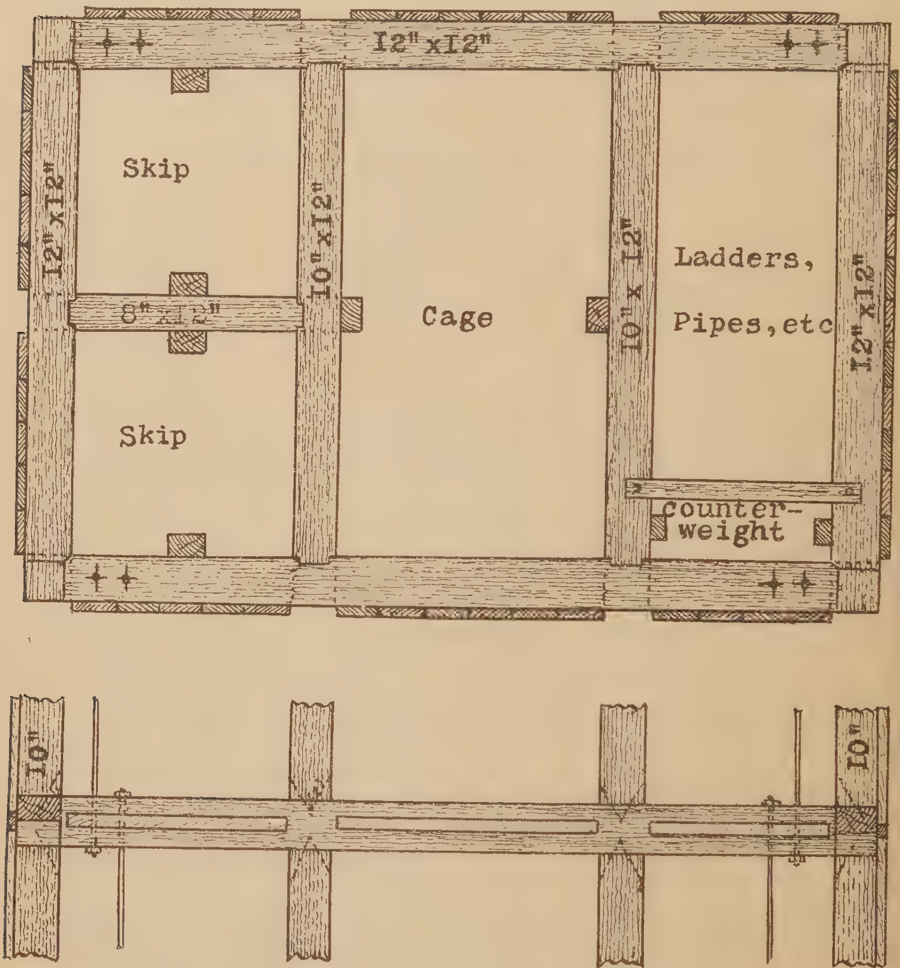


FIG. 35.—Frame-set for another type of four-compartment shaft.

merely necessitates the use of longer wall-plates and central divider, and the addition to each set of a further pair of short cross-dividers, no special description of the type is called for. The Red Jacket Shaft of the Calumet and Hecla Mines in the Superior district of U.S.A. is a six-compartment one of this type, and is about 5000 feet in depth. It is 23 feet by 13 feet 6 inches within the timbers, which are of 12-inch by 12-inch section. Two of the compartments at one end are used respectively as an upcast airway and a ladder-way, the two middle compartments for lowering or raising men, and the remaining two for haulage purposes.

Apart from what may be termed the regular double-width type, other designs are at times adopted which may be classed as a combination of it

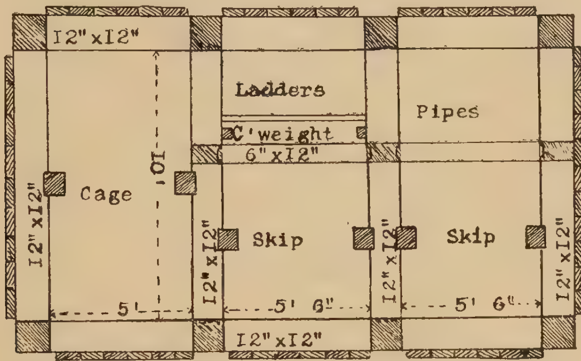


FIG. 36.—Frame-set for five-compartment shaft.

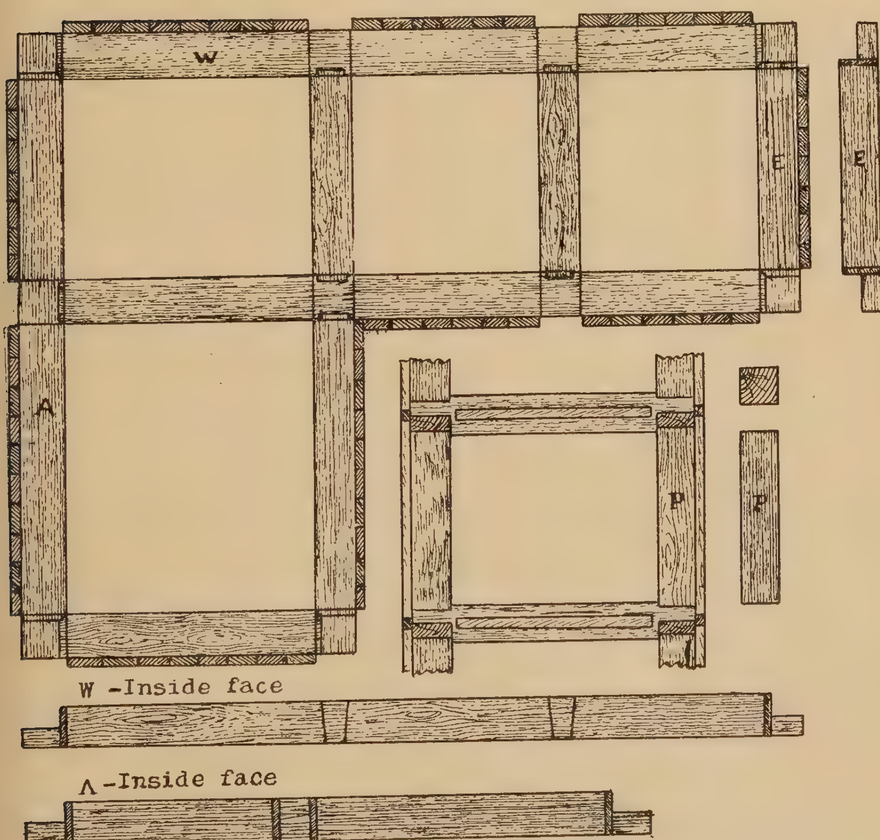


FIG. 37.—Frame-set for L-shaft.

with the ordinary single-width shaft. Two typical examples are shown in figs. 35 and 36. The framing of the sets for shafts of this kind presents no

unusual features, all the joints being made in some one or other of the ways previously illustrated.

The design known, from its distinctive shape, as the L shaft is rarely adopted in modern mining, but was occasionally made use of in past days. The great difficulty experienced in sinking and timbering shafts of this type, combined with the fact that their unusual form offers no advantage that cannot be met by a shaft of the true rectangular design, are good reasons why it has not been more widely adopted. Fig. 37 shows the timbering

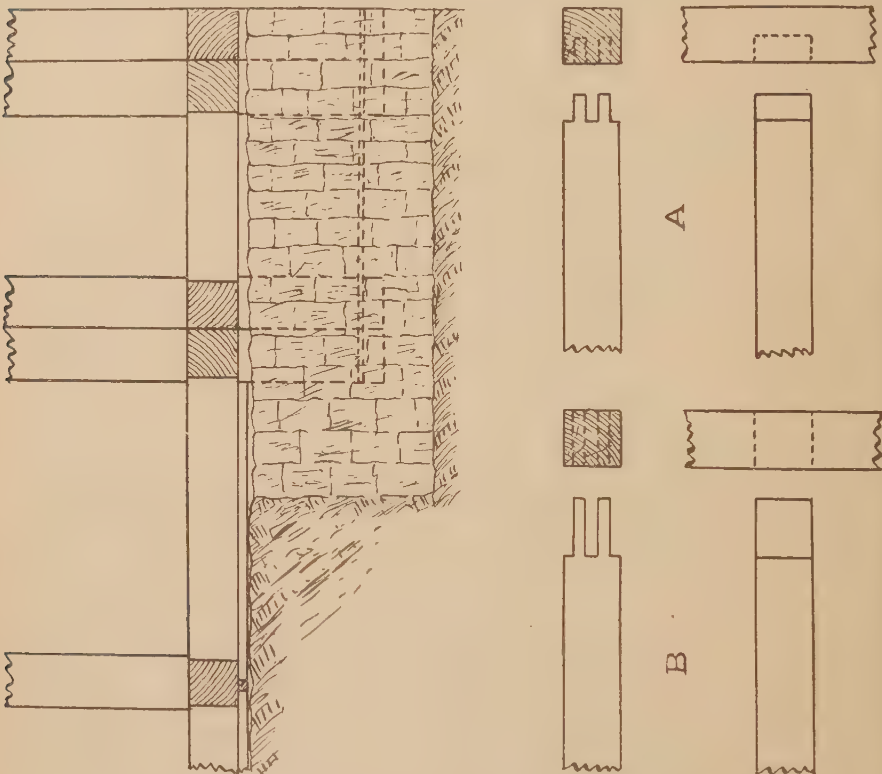


FIG. 38.—Collar-sets for large frame-set shaft—South African method.

of a shaft of this kind mentioned by Storms (9) as having been put down by the Overman and Caledonia Silver Mining Company at Virginia City, Nevada, U.S.A.

Collar-Set for Frame-Set Shaft.—The necessity of making the starting-set of a shaft permanently secure has already been referred to in previous pages. In a frame-set shaft much the same methods of preparing and placing this set are followed as in the case of a boxed shaft, but the need of having it strong and rigid is more insistent, by reason of the fact that, besides giving alignment to the shaft and supporting part of the poppet-head, it has also to help in supporting the shaft timbers, which are hung from it. If the surface forming the brace is fairly solid, a set such as shown in fig. 10 is used, but the horns are left longer. If the brace is on built-up ground the set, instead of being merely placed on

the filling, is supported on masonry or concrete pillars or walls erected well outside the shaft timber.

On the Rand goldfields of South Africa, where the shafts have usually to be carried to considerable depth, the practice is fairly general of jointing the main members of the brace-set as shown in fig. 38, two tenons being provided at each end of the end-plates, which enter mortices cut in the wall-plates to receive them. Sometimes these tenons and mortices only correspond in depth to half the thickness of the timber used, as at A, but they are occasionally prepared as at B. The horns on the wall-plates are left of sufficient length to rest upon walls of masonry or concrete built up across the shaft ends. The walls are carried down to solid rock. Frequently a similar set is placed immediately under that at the surface, and it is not uncommon

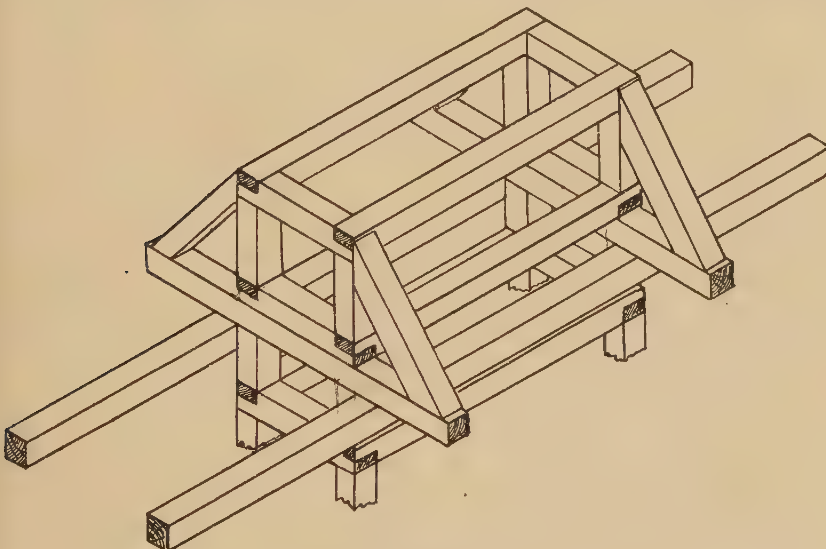


FIG. 39.—Collar-set for frame-set shaft in weak ground.

for the first regular set below the brace to be of a like kind. When these methods are followed, the horns of the sets are let into the concrete or masonry, and bolts are passed through them to further secure the whole construction.

In cases where the ground near the surface is very loose but it is not desired to use concrete or masonry walls, other arrangements to give strength to the set may be resorted to. One of these, described by Davenport (27) as having been adopted at a shaft in the Chisholm district of Minnesota, U.S.A., is shown in fig. 39. In this case, after the alignment of the shaft had been determined, two level trenches were dug on the surface, and in them were laid, well outside the regular shaft-timber, two heavy bearers, 40 feet to 50 feet in length. The upper sides of these were levelled up, and across them, with their inside edges in alignment with the inside of the end of the shaft, were placed two cross-pieces each about 20 feet in length. On these cross-bearers the first set was then put in place, with the end-plates resting on them. Following this, the first set below the carriers was put in. The corner posts of the lower set fitted into daps previously cut in the under faces of the cross-bearers,

and they were shorter than the ordinary posts by the thickness of the timber used in the bearers. Hanging bolts were used to secure this lower set to the bearers, and in each succeeding set. The set forming the shaft collar was then erected and braced, as shown, to the bearers. Straight one-piece bolts, which passed through the cross-bearers as well as the end-plates of the two sets above them, were used to further secure the collar-set. Lagging was then placed round the upper sets, and as dirt was hauled it was heaped around them till the general surface was on a level with the top of the timber. It will be noted that, with the exception of those of the top sets forming the collar, the side-plates of the shaft-sets rested on the end-plates, a method of frame-setting not in accordance with customary practice, with the consequence that instead of the hanging bolts directly supporting the wall-plates, which are by far the heavier members of the sets, they pass through the end-plates, and are thus not in a position to give the greatest measure of

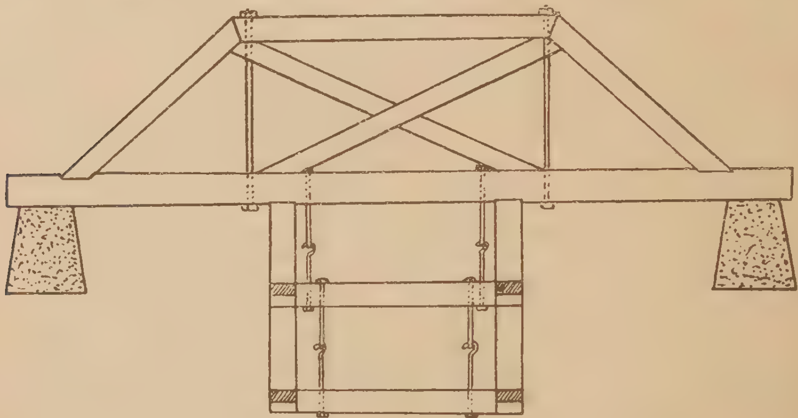


FIG. 40.—Another method of securing collar-set in weak ground.

support to the frames as a whole, or permit of as rigid tightening up of the timbers as is desirable.

Another and somewhat similar method of strengthening the collar-set is shown in fig. 40. This method may prove suitable in the case when a shaft is being sunk in running ground where fore-poling is necessary, and is not necessarily of as permanent construction as that just described. In ground of the character mentioned, blocking and wedging of the sets cannot be carried out in anything approaching the effective way possible under other circumstances, consequently more of the weight of the shaft timbers has to be carried by the brace-set than would otherwise be the case. A truss of the kind shown will, under such conditions, serve its purpose well. Once the shaft has been carried down to firm ground, and the weight of the set timbers taken up by bearers, the truss may be removed.

Placing Frame-Sets in Position.—The method of carrying out this work differs from that of placing box-sets, inasmuch as it is done downwards from the last timber put in instead of upwards from bearer-sets. If the timber has to be put in as soon as room is made for it, as is often necessary, the placing of the sets is a comparatively simple operation, the timbermen being able to work in comfort from a solid footing on the broken rock in the shaft bottom. If, however, the sinking has been carried down for any considerable distance below the

last timber, as mine managers often aim at doing with a view to lessening injury to the timber from blasting, a staging must either be laid on stulls placed across the shaft and securely hitched into the walls, or else a swinging stage must be provided. The last method is the more common and convenient practice. An ordinary way of making the staging is to place two strong bearers across the shaft, one near each end, resting either on the collar-set or on the second last set of any previous timbering, and from them hang the stage by means of chains made of $\frac{3}{4}$-inch iron. Four chains are used, one for each corner, and each is provided with a hook at one end and a shackle at the other. In each of the bearers eyebolts are inserted a few inches from either side of the shaft, to which the hooked ends of the chains are attached, the shackle end being used to secure the stage. The latter consists of two further bearers long enough to reach from one end of the shaft to the other within the timber, across the ends of which pieces of strong planking reaching from side to side of the shaft, also within the timber, are bolted to form a rectangular frame. The lower ends of the chains are passed around the long bearers of the stage, and made fast by means of the shackles. Over the frame, planking of suitable length is then laid to form a floor.

The staging being in place, a start is made at the actual work of putting in the new set by first placing the upper halves of the hanging bolts—usually of from $\frac{7}{8}$-inch to 1-inch iron—in the holes previously bored for them in the last set put in, after which the first wall-plate is lowered. To prevent unnecessary handling of the timber, which can easily be a troublesome task in the narrow confines of a shaft, it is customary for the workmen to make previous arrangements as to which wall-plate is to be lowered first. The lowering of the timber is done by means of the shackle already described, and, the plates being heavy, this is usually attached to them near their centre, one end of the piece of timber being lashed up to the rope so that it hangs as nearly vertical as possible. On reaching close to the stage the lashing is removed and the plate swung into a horizontal position. The lower halves of the hanging bolts are now inserted in it, their nuts and washers placed on them, and by means of the rope the plate is raised or lowered until the hooks of the hanging bolts can be connected. The other wall-plate is then sent down and dealt with in a similar manner, after which the end-plates are put in position. After the dividers have been set in their mortices and the posts stood in their respective daps, the whole set is tightened up by screwing up the nuts on the hanging bolts. If spliced wall-plates are used, the two pieces forming one side are, as a rule, sent down and hung on their bolts before those for the other side are lowered. In the case of a very long shaft, it may be necessary to have two swinging stages, end on to one another.

Aligning Frame-Sets.—Great care is called for in seeing that frame-sets are true in both vertical and horizontal line. It is as important to have each set level as to have it perpendicular to the timber above it. If a set is not in vertical alignment, there is the probability that all succeeding sets will also be out of correct line, and the position is usually aggravated as the timbering proceeds. If error creeps in in levelling the sets it can be remedied by cutting the posts of one or more sets in such a way that future timbering can be brought into proper adjustment, but little can be done by way of levelling up sets that have once been blocked and packed, and even the shortening of posts is at best an unsatisfactory procedure to have to resort to. Several methods of aligning sets are in common use. The best way to ensure true line being kept is to make frequent use of the transit, but this practice is not often followed. Very often the work is effected by means of plumb-lines hung in the corners of the shaft,

as described in the sections dealing with box timbering. The ordinary method of carrying out alignment is by using a straightedge, 15 feet to 20 feet in length, a spirit level, and a set-square. The straightedge is stood in the corners of the shaft so that it touches at least two sets above the one that is being placed. This plan is not as reliable as could be desired, owing to the liability of the straightedge to warp. A better method is to use a combined straightedge and plumb-line, as shown in fig. 41. This straightedge is made sufficiently long to touch at least three sets, and should be dressed from well-seasoned timber, 5 inches by $\frac{3}{4}$ inch. Near the centre of it a narrow cleat is fixed, from which the short plumb-line is suspended. Towards the lower end of the straightedge a hole is cut in it to allow of the bob or weight on the end of the line swinging freely. About half-way between the bob and the cleat a staple is placed to limit the swing of the line, and down the face of the straightedge a mark is drawn with which the plumb-line should coincide when the appliance is truly vertical.

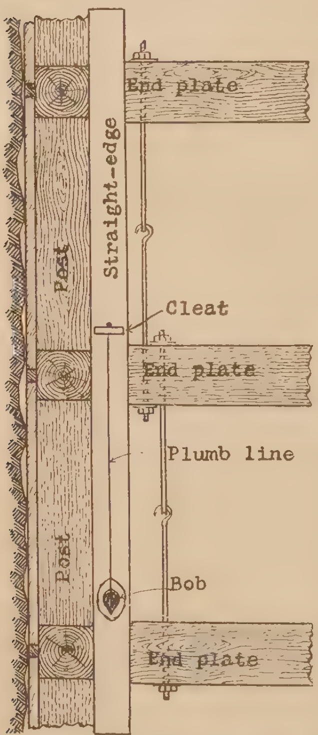


Fig. 41.—Method of aligning frame-sets.

In operation, the straightedge is stood near the corner of the shaft, and when the new set is in proper vertical line should touch its inside face as well as the inside faces of the sets above. If care is taken in using this appliance and the new set is simultaneously brought horizontal, as shown by the spirit-level (the necessary adjustments being made by tightening up or slacking off the nuts on the hanging bolts), a very high degree of accuracy in placing the timbers can be attained. It may be said, however, that if the timbering is in the hands of experienced men, the vertical alignment of any kind of shaft timber can be carried out as accurately merely by use of the ordinary plumb-lines as in any other way. This method of aligning is followed very commonly in Australia and New Zealand, and, judging by the remarks of such well-known writers on mining subjects as W. H. Storms and Robert Peele, is largely favoured in America. In the latter part of the world, the practice is sometimes adopted of marking the wall-plates with a slight saw-cut at a measured distance from the corner, the marks being made before the timbers are sent down the shaft. The plumb-lines are then suspended from these marks higher up the shaft, and when the new set is in alignment should coincide with the marks on it. If the timbermen are skilful at their work, it may be sufficient to hang the lines in the diagonal corners of the shaft, but they are often hung at all four corners. The making of a saw-cut such as mentioned is not approved by experienced mining men, as they hold there is a danger of the plate subsequently splitting at it if any serious pressure is offered, and, to obviate this, other methods of marking the timber, such as driving bright-headed tacks, have been advised.

Wedging, Lagging, and Packing Frame-Sets.—Each set is blocked and wedged as it is put in alignment; in fact, much of the adjustment is effected

by driving the wedges on one side or the other. The wedging is done in the same way as with box-sets (fig. 42), outside both end- and wall-plates near the corner and opposite the dividers, the corner wedges being tightened first. If the ground is heavy and only one set is being put in it is lagged at once, the lagging, which is usually of 8-inch by 2-inch, or 8-inch by 3-inch timber, being stood on the cleats previously nailed to the outside of the plates. Should a space of any size be left between the timber and the wall, poles are laid in to keep the packing from falling through. To enable the packing to be done effectively, one piece of the lagging is left out on each side and end till the last moment. When the space has been filled as well as possible, the upper ends of these pieces are then driven up behind the frame-set next above, when the lower ends may be drawn down into their places by using the point of a pick. In case much loose packing has to be put in, the lagging is sometimes put in horizontally instead of vertically. If sinking has been carried well down below the standing timber, and a number of sets are to be placed at the one operation, it is usual to leave the packing and lagging till all the sets have been put in, when a start is made at the bottom set and the work carried upwards till completed. In this case, the lagging of all the sets except the last is stood vertically, but that of the top one may be placed horizontally. The swinging stage is not required for this work, as the men can readily place such staging as they need across the sets.

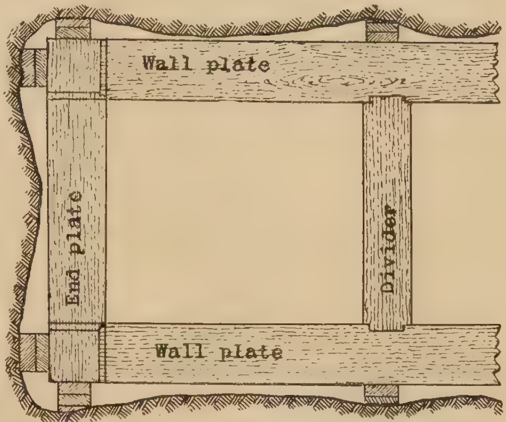


FIG. 42.—Method of wedging frame-sets.

Dividers in Frame-Sets.—The tenons on the ends of dividers are usually 1 inch deep, but, if the wall-plates are of very large section, they may be up to $1\frac{1}{4}$ inches or even $1\frac{1}{2}$ inches. They are invariably cut with a bevel. Sometimes both sides are bevelled as at A (fig. 43), at others only one side is so prepared, as at B. In any case the tenon is placed centrally in the cross-section of the divider, and never at one side as at C. Occasionally, also, the face of the tenon is bevelled as at D, but the practice most generally adopted is to cut it with a straight face as at E. As they have to stand a good deal of end pressure, especially when the shaft is sunk in heavy ground, the dividers need to be, as a rule, of timber of fairly large section, but they are frequently made of material somewhat smaller than that used in the end- and wall-plates. Thus, if the latter be of 12-inch by 12-inch timber, the dividers may be of 12 inches by 8 inches, or 12 inches by 9 inches, the object

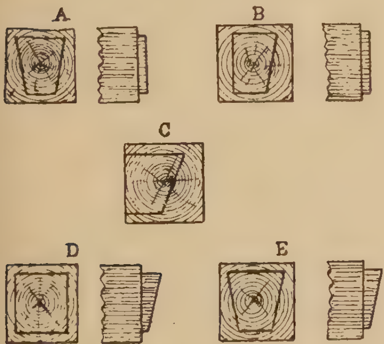


FIG. 43.—Various methods of jointing to secure dividers.

being to avoid taking up any more of the compartment space than is absolutely necessary. In all such cases the longer side of the timber is placed in the perpendicular direction. Whatever may be the size of the divider or the depth of the tenons, the latter are always covered by the bottom of the posts, the idea being partly to prevent the divider being shifted out of its place through being struck by flying debris from blasts, and partly to obviate any chance of it being sprung out by pressure from the walls.

When it is necessary, owing to the bad standing character of the country that is being penetrated, to keep the timbering well down to the shaft bottom, the dividers cannot always be put in at the time the frame-set is placed in position. The posts of each set must of necessity be stood in place prior to aligning and tightening up, but owing to the fact that their closeness to the shaft bottom would prevent the long wall-plates of the next set being carried into position, the dividers have frequently to be left out for the time being. In these circumstances, special provision has to be made to enable these members

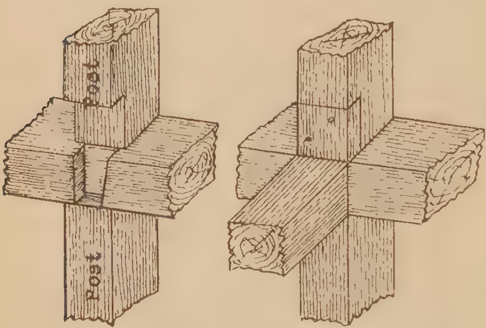


Fig. 44.—Inserting dividers after plates have been wedged.

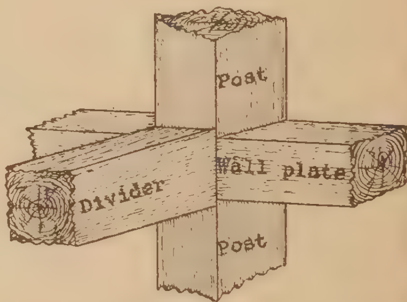


Fig. 45.—Using large divider to prevent posts or studdles being forced inward.

of the set to be put in subsequently without undue trouble. The operation may be, and is at times, performed by spreading the wall-plates with a jack-screw sufficiently to permit of the tenons of the dividers being entered in their mortices, but if the sets have been previously wedged and packed this method of getting them into place is often attended with much difficulty. The adoption of the Montana method illustrated in fig. 44, and described by Storms (12), affords an easy way of carrying out the work. Prior to a post being put in place, a piece is cut from it at the lower end, corresponding in depth with that of the tenon on the divider. When the time comes for the latter to be put in, it is slipped sideways into the space thus provided, when it will readily drop into its permanent position. A small piece of timber cut to size is then spiked to the post to replace the portion previously cut away.

When very heavy pressure is exerted on the sides of a shaft, there is a tendency for the posts, even when provided with daps at top and bottom, to be forced from their position, and it is the practice on some mining fields, in order to minimise the possibility of this occurring, to use dividers of such a size as to offer a check to the post, as shown in fig. 45. In this case, the divider is in one piece, but it is about 2 inches deeper than the wall-plate, and is put in in such a way that a shoulder 1 inch deep is offered to the bottom of one post and the top of that next below.

Another method of effecting the same purpose is that of using a double divider, as in fig. 46. This plan was followed in the timbering of some of the

larger four-compartment shafts on the Comstock lode, Nevada, U.S.A., timbers 14 inches square being used for the wall- and end-plates and for the posts, while the two pieces forming the double dividers were each 12 inches square.

Partitioning Off Compartments in Frame-Set Shafts.—It is not usual for the haulage compartments of a shaft to be closely partitioned off one from another, but it is common practice to so close off the ladder-way, if only for ventilating purposes. This is usually done by setting short planks horizontally between the posts or studdles. These are either secured by nailing cleats vertically to the posts on either side of them, as in fig. 47, or by entering their ends in slots or grooves previously cut in the posts, as in fig. 48. When the latter method is followed, the partitioning must be done simultaneously with the putting in of each set, and before the lagging has been put in, thus making the task of the timbermen in properly tightening up the whole set somewhat more difficult than if the first-mentioned method is followed. The securing of the partition in this way makes, however, a much more permanent job. One great advantage of the cleating method is that the planks can be put in at any convenient time, and this often leads to it being adopted in cases when the timbering has to be kept close to the shaft bottom; its most serious disadvantage is that the nails

Fig. 46.—Method of using dividers in pairs.

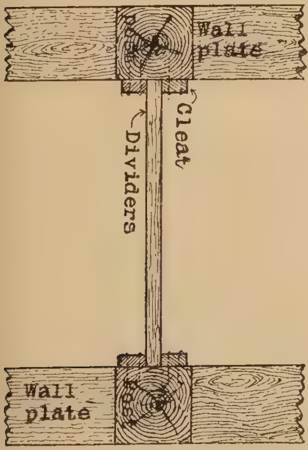


Fig. 47.—Partitioning off compartments.

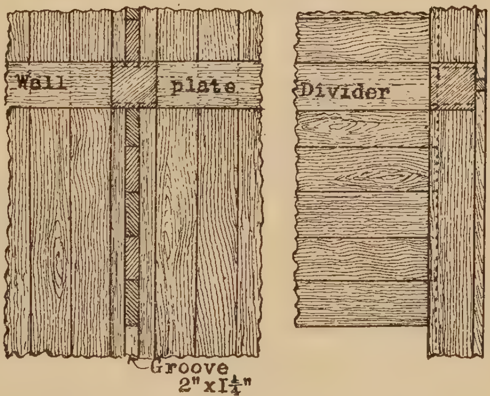


Fig. 48.—Partitioning off compartments.

holding the cleats are liable in certain circumstances to be quickly eaten away by the action of acids in the mine water, with the result that the planking falls from its place (gets adrift) with possible serious effects to the workmen.

Bearers in Frame-Set Shafts.—Where it is the practice, as is commonly the case, of leaving the hanging bolts permanently in frame-set shafts, the custom of putting in bearers to support the timbering is not always followed. It may be said, however, that the more generally approved practice is to use bearers in all cases, the hanging bolts being also left in if preferred, or merely employed temporarily until the weight of the timber has been taken by the bearers. Strong bearers securely hitched into the walls are a great help in preventing displacement of the timbers through the wedging of the sets failing, from any cause, to effect its purpose. At times the plat or station sets are made to act as bearers, in which case the hanging bolts are left in till the timbering has been completed from plat to plat, but the more approved practice is to put bearers in at regular intervals of about 50 feet. These bearers consist usually of a pair of strong beams placed across the shaft as in fig. 49, with their inner faces flush with those of the end-plates. The timber used should

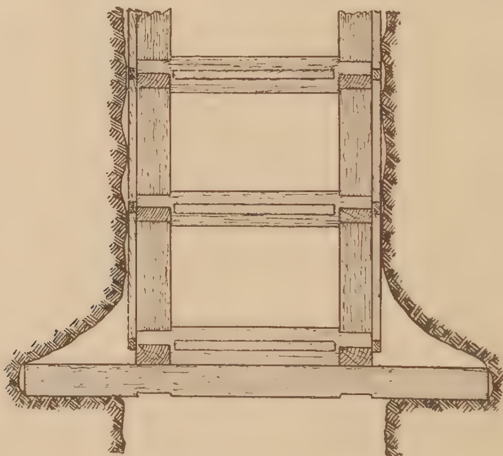


FIG. 49.—Bearer-set for frame-set shaft.

be at least of the same cross-section as that from which the ordinary sets are made, but is usually of larger dimension. No change is made in the framing of the ordinary set that rests on the bearers, but daps are cut in the underside of the latter for the reception of the corner posts of the set that will go in below them. These posts are shortened by a length equal to the depth of the bearers, but the other posts of the set are of the usual length. In some instances the end-plates of the set immediately above the bearers are bolted to them, but no very useful purpose is served by doing this. Bearers of this kind cannot be put into place until the set directly above them has been placed in alignment and securely wedged. To permit the bearers to be then put in without difficulty, hitches are cut for them prior to the set being put in. If the ground is of good standing nature these hitches need not be more than a few inches deep, in which case they are cut in such a way that the bearers are entered into them sideways from inside the ordinary timbers. If the ground is weak, it may be necessary to use bearers much longer than the width of the sets, and, consequently, deep hitches will require to be prepared. Fig. 50 shows a method described by Davenport (27) as followed at the Minnesota Iron Mines, U.S.A., in getting the bearers into place in such cases. The shaft

itself was 8 feet wide, but bearers 16 feet in length were used. Small drives, about 3 feet by 4 feet, were run in at diagonal corners of the shaft for 8 feet, and at the other corners for 4 feet. The inside corners of the 8-foot drives were cut away to give easy access to the bearer. The bottoms of the drives were then levelled and laid with cross-timbers consisting of short pieces of planking. When a bearer was brought down, one end was first carried into

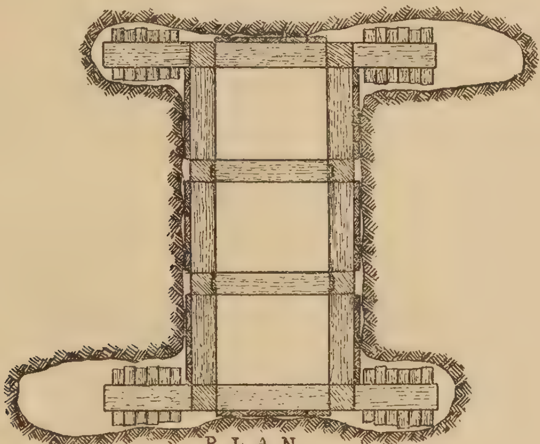


Fig. 50.—A method of putting in bearer-set.

the 8-foot drive, and its other end brought back for 4 feet into the shorter drive opposite. The other bearer was then dealt with in a similar way, after which both bearers were brought into alignment with the shaft timber and tightened up against the lower set by driving wedges underneath them, on top of the flooring planks. After the bearers had been properly secured, the drives were filled with suitable packing.

In mines where the timber used is of large dimensions, and consequently very heavy, bearers are also sometimes placed across under the dividers.

TIMBERING SHAFTS WITH STOPING SQUARE-SETS.

The use of the square-set (in the sense that the term is applied to stope timbering) is not resorted to in timbering main working shafts, but is common in timbering winzes, especially in mines where square-setting is the customary method of supporting stopes, the winze timber later on becoming part of the general stope system. Some fairly deep shafts have, however, been timbered from surface in this way. The method of timbering one such shaft for a depth of over 800 feet on the Lake Superior Mining Company's property, Michigan, U.S.A., has been described by St. G. Campbell (56), and is shown in fig. 51. It will be seen that it is an adaptation of the ordinary stoping square-set to shaft purposes. The shaft was sunk 10 feet wide by 18 feet long. When 10 feet had been sunk, a double square-set, 8 feet by 8 feet by 16 feet was set up, the timbers of each being hung from those of the set above in much the same way as such sets are hung in underhand stoping, each set being wedged and lagged in the ordinary way as it is erected. Another 10 feet was then

sunk, and another double set stood, and so the work proceeded. Timber of from 12 inches to 18 inches diameter was used. When a lift had been completed the shaft was lined inside the square-sets with 8-inch by 8-inch

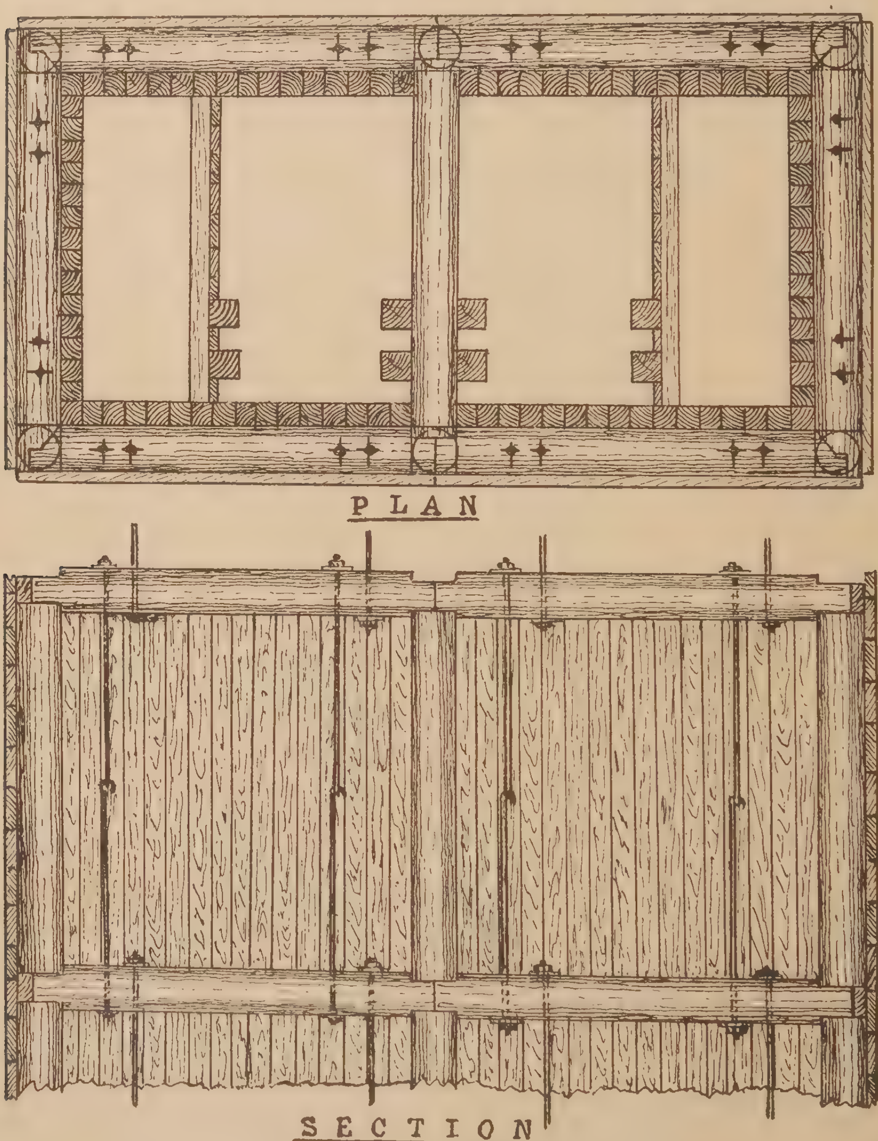


FIG. 51.—Use of stoping square-set in shaft construction.

square timbers, 18 feet long, placed close to one another vertically, and spiked to the set timbers, thus giving the shaft a box-like appearance. In each set, and parallel to the ends of the shaft, cross-pieces were secured, to which planks were nailed, dividing the shaft into four compartments, the centre two of

which were about twice the size of the end ones and were used for skip-roads, the end compartments being used for pipes, pumps, ladders, etc. Two 8-inch by 8-inch runners were bolted on either side of the haulage-ways, which served as guides for the steel boxes used as skips.

SPECIAL TIMBERING PROVISIONS FOR RESISTING SIDE PRESSURES IN VERTICAL SHAFTS.

In nearly all mining districts pressures are found to exert themselves against the shafts, leading to the breaking or displacement of the timbers. At times the trouble caused may merely amount to the occasional bursting of a wall-plate, but in certain mining districts so great are the pressures exerted by swelling or flaking ground that the ingenuity of the mine operator is tried to the utmost in the effort to keep maintenance costs within reasonable limits, if not to save his shaft from complete destruction. In Australasia, no very serious trouble of this kind has been experienced, but in America, particularly in the Butte and the California mother-lode regions, it has been the cause of great anxiety to mine managers and owners. Many schemes have been tried in the effort to minimise the heavy cost involved in the task of keeping shafts in safe working condition in these districts. The Butte and Superior Company at Butte abandoned the frame-setting method of timbering in portions of several of its shafts in favour of close timbering. According to Parsons (2) the standard shaft timbering at this mine prior to 1917 had always been regular rectangular sets, with wall- and end-plates 12 inches by 12 inches, and dividers 12 inches by 7 inches, spaced at 4-foot to 5-foot centres, and lagged with 2-inch to 3-inch plank. The cost for repairs and maintenance became so excessive, however, that it was necessary to develop a better method of timbering the openings. The ground was a soft granite, which was blocky, and slaked readily on exposure. After much study, a form of cribbing consisting of 12-inch by 12-inch timbers laid skin to skin was resorted to in those portions of the shafts where the most trouble was experienced. Instead of the frame-sets, the shafts were lined in these parts with a continuous wall of 12-inch by 12-inch timber in sets which were framed by halving at the corners, each set being well-blocked against the rock. This change in the method of timbering was found to serve the desired purpose very satisfactorily.

Whether the style of timbering adopted in the case mentioned would give equally good service in really bad, swelling ground is doubtful. The experience of many mining engineers has been that the closer the timber is set in such ground the greater is the effect of the pressure on it, and, consequently, of the damage done to it. Modern practice—the result of long experience—is rather in favour, in such circumstances, of leaving openings in the timbering through which the force of the pressure can exert itself, or through which the swelling ground can be drawn out to relieve the weight on the shaft. When the swelling is not excessive, provision in this direction can be made in a boxed shaft by spacing the sets, and in a frame-set shaft by leaving openings between the lagging. When the pressure exceeds the limit at which sufficient relief can be given in this way, more elaborate methods are called for. Of these, that of using *jacket* or *easer* sets outside the regular shaft-sets has been employed with a good deal of success. The construction of these sets is shown in plan and section in fig. 52, which represents a three-compartment shaft jacketed all round. As will be seen, a sort of reinforcing set is placed around

the shaft with its inner faces about 2 feet outside the regular set. At each corner, and opposite each divider, sprags SS are placed between the two sets, and on them planks are laid to form a platform. On the outside of the jacket-sets lagging is placed vertically in the ordinary way, but spaces of about 6 inches are left between each plank. Through these openings the workmen, whenever excessive pressure is noted, pull the swelling ground with picks on to the platform, from which it is shovelled into a skip for removal. If necessary for convenient working, the lagging can be removed one piece at a time. For extra security the lagging is usually of heavier material than is ordinarily used

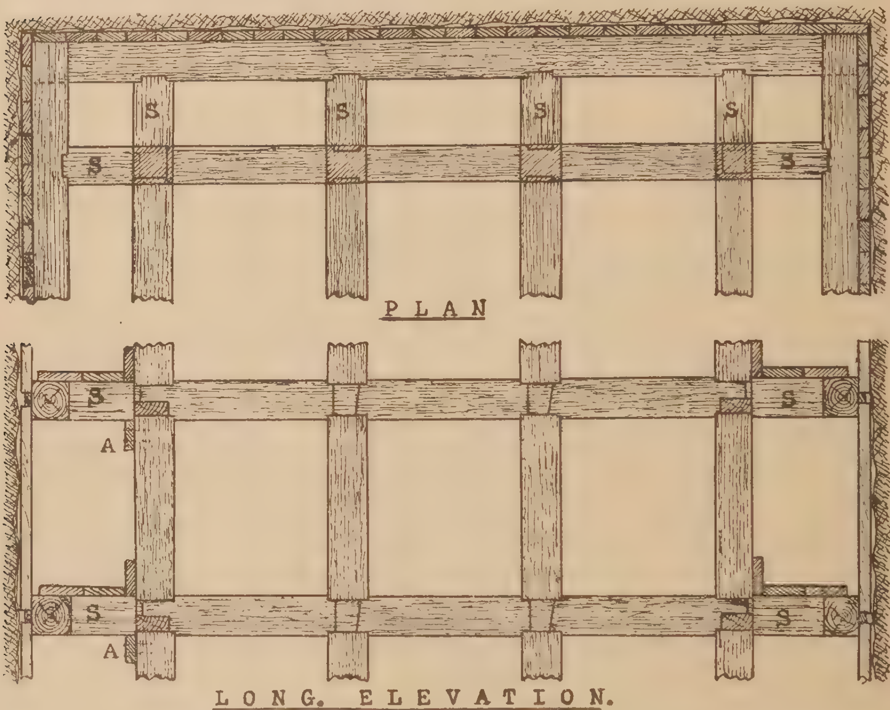


FIG. 52.—Jacket or easer sets used in heavy ground.

for the purpose, say of 8-inch by 4-inch section at least. This method of relieving shafts has given satisfaction on American mining fields. Where the pressure is continuous a gang of men is kept constantly in the shaft, moving from platform to platform to ease the weight on the timbers. The sprags between the inner and outer sets may be secured either by providing them with tenons that enter mortices prepared in the respective sets, or by having cleats nailed below them.

For resisting heavy side pressure, another method is that described by Le Neve Foster (3) as being practised at Clausthal in the Hartz region of Germany, but it is not one that will appeal greatly to English or American mining engineers. Fig. 53 shows, in plan and section, the way in which the timbers are set in this method. AA and BB are the wall- and end-plates respectively, and EE the posts of the regular shaft-set. The plates are not halved to make the corner joint, each piece being left as strong as possible.

To secure the ends in place the only provision made is to cut a slight joggle in the wall-plate. Inside the regular set, near the ends and at the middle of the shaft, the posts CC, about 18 feet to 20 feet long, are stood, and these are kept apart by the diagonal struts DD, known as strompels or spur timbers. The

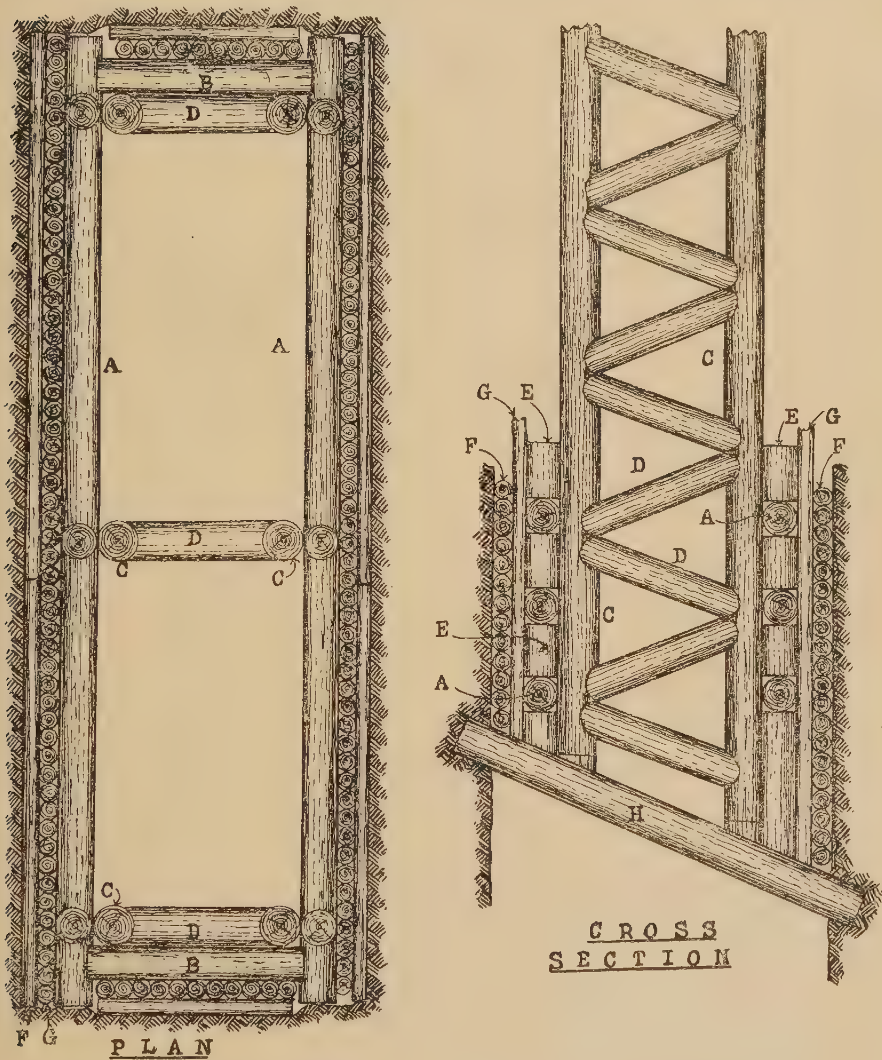


FIG. 53.—Clausthal method of reinforcing shaft timbers in heavy ground.

lowest of the latter fits, at its foot, into a hitch cut in the wall post, while its head is merely collared to fit on the opposite post. The remaining diagonals are collared at both ends. Once the bottom ones are in, the others are readily put in place. If thought necessary, bearers H are hitched into the rock walls to carry the timbers. For lagging purposes, small poles are used in two layers, the inner placed vertically, the other horizontally.

TIMBERING VERTICAL SHAFTS IN RUNNING OR WATER-CHARGED GROUND.

The sinking of timber-supported shafts in ground that runs easily is at all times a difficult task, but by the adoption of special ways of placing the timbers it may be carried out successfully even under most unfavourable conditions. If the ground is merely of a loose nature, and liable to run if an undue opportunity is given, but is not heavily charged with water, the method known as fore-poling is usually followed. This consists of driving sheet-piling in advance of the sinking, or, in the case of only moderately bad ground, simultaneously with it. This method is shown in fig. 54. The ground is first taken out to

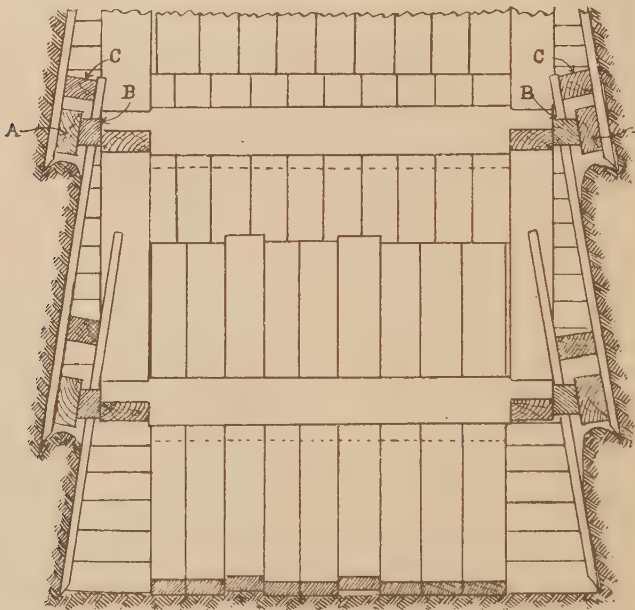


Fig. 54.—Section showing fore-poling method of shaft timbering in heavy ground.

admit of the insertion of two frame-sets. A start can then be made to drive the piling. Bridges AA, consisting of stout lengths of timber, are placed outside the bottom set, and separated from it by wedges or blocks BB (see also fig. 55) set near the corners and opposite the dividers. These wedges should be of sufficient size to admit of the free passage of the piling between bridge- and wall- or end-plate. Thus if the piling is 3 inches thick, the wedges should be 4 inches. The piling (in this case planks of 6 inches by 3 inches, or 6 inches by 2 inches, and about 6 feet long) is then placed, piece by piece, in the opening thus afforded, the lower end of each plank being trimmed to wedge-shape for convenience in driving, and is driven down as far as possible, with the lower ends looking out a little from the shaft. No greater force is used in the driving of the timbers than is absolutely necessary to advance them without doing them injury. To prevent the lower ends of the piling turning inwards, other lengths of timber CC, termed tail-pieces, are placed, as shown, between their upper ends and the piling of the upper set. If the ground is fairly dry, excavation of the shaft is carried on simultaneously with the driving of the piling,

the latter being advanced little by little as sinking progresses until it has been driven its full length, when, the necessary room having now been provided, a new set is put in and hung from the one above, and so the work goes on.

At the corners of the shaft it is not possible to drive piling to cover all the ground opened, a triangular space being left between the first plank on one side and that on the end. If intermediate posts are used in the sets opposite the dividers, other spaces are also left between the planks forming the piling. These spaces are filled as shown in fig. 55 by small pieces of planking, known as coping-boards, which are put in as needed, one at a time, as room is made during the progress of sinking. The work of driving piling of this kind calls for some experience and a good deal of care on the part of the men engaged

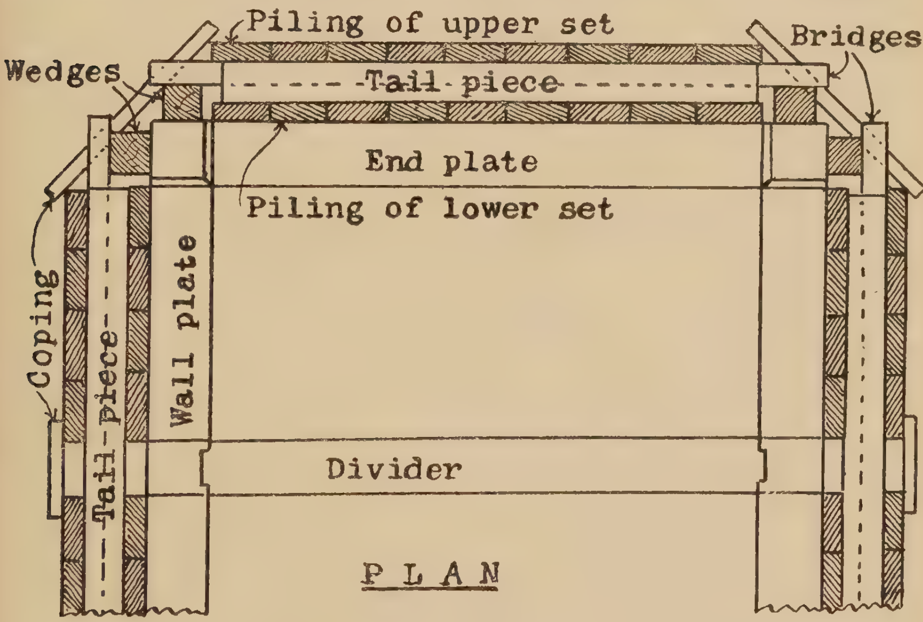


FIG. 55.—Plan of fore-poling method.

at it, as hasty or indifferent workmanship may easily lead to a run of loose material from behind the timber, with the danger of opening up caves and causing much subsequent trouble in holding the shaft. The piling should be kept well down to the bottom of the excavation, and the separate planks driven as evenly as possible and closely together. With care in attending to these points a shaft can be carried down successfully through very troublesome ground.

When the ground being penetrated is of such a nature that it swells rapidly in the bottom of the shaft, it may be necessary to use planks to floor the bottom in much the same way that breast-boards have sometimes to be used in a drive. In this case the planks are laid across the shaft in the short direction, and are held down by the laths, or piles, that are being driven at the shaft sides. In sinking, these planks are removed one at a time to admit of their being replaced in position a little lower, when the side piles are advanced to meet them and secure them in place. The use of floor planks in this way necessitates, however, the employment of either cumbrously long timber, or

else of specially prepared planking consisting of two pieces held together by thumb-screws and provided with slots to admit of extension or shortening. A more convenient way of carrying out the work is that shown in fig. 56, which is after an illustration by Ihlseng (5). Here the floor planks are held down by *toms* or stays from the set above, the whole floor being covered except a small opening at the centre of the shaft, which is advanced by fore-poling, and afterwards gradually opened out to the full size of the shaft. It is necessary to have at hand a supply of stays of various suitable lengths for use as the general level of the shaft bottom is lowered.

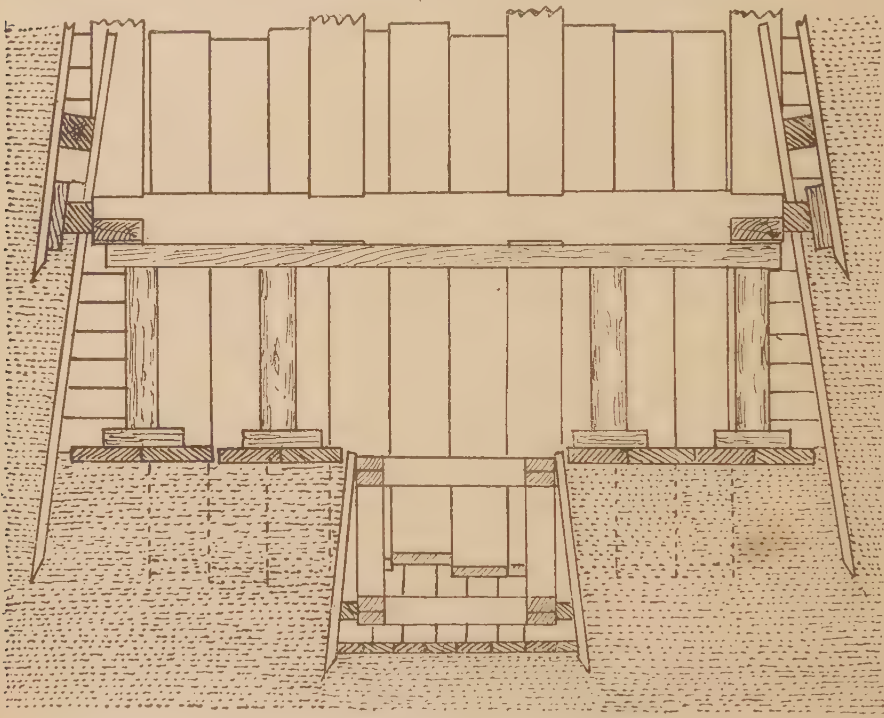


FIG. 56.—Fore-poling when bottom swells rapidly.

In ground that is not actually quicksand or extremely heavily charged with water, but which contains water in such quantity as to make it more difficult to hold than in the cases previously referred to, more elaborate and costly methods of timbering have to be resorted to. One of these is shown in fig. 57, in following which vertical sheet-piling is used. In this method no bridges are needed, the piling being driven vertically around the shaft in such a way as to form a complete, practically water-tight wall. To ensure this wall being as water-tight as possible, the piling is splined, or tongued-and-grooved, so that the individual pieces sit closely together. In starting a shaft which is to be timbered in this way, two full frame-sets, spaced about 5 feet apart, are first put in, below the surface of the ground if the latter is sufficiently firm to allow of this being done, or above the surface if it is not. The piling is stood around the shaft against these sets, and, if necessary, waling pieces are bolted to the top set to hold the planks in place. Excavation of the ground inside the shaft

is then begun, and as it proceeds the piling is driven down, but in very bad ground the piling is driven ahead of the actual sinking.

To prevent the piling getting out of line, and at the same time make it as water-tight as possible, the separate pieces are prepared in one or other of the ways shown in fig. 58. The first of these, A, is known as the Wakefield sheet-pile, and consists of three pieces of timber held together by screws, B represents a piling prepared with tongue-and-groove in the same way as an ordinary building floor-board, while C is known as a splined piling, and is formed by spiking cleats on a rectangular piece of suitably sized timber. Interlocking metal pilings are also used, but need not be described here.

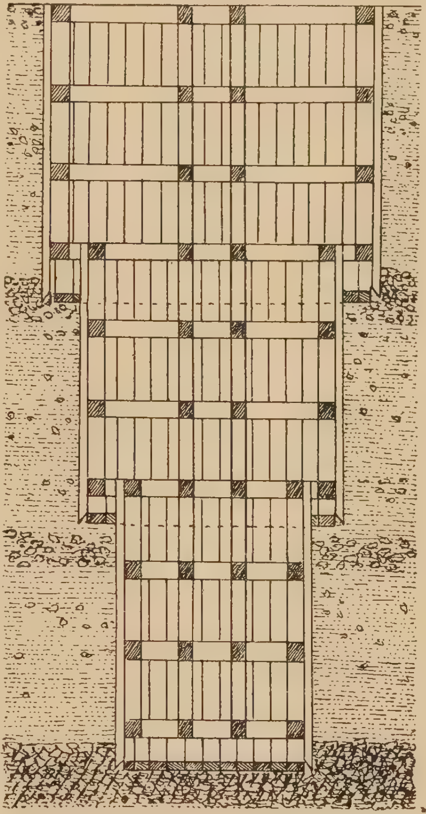


FIG. 57.—Sheet-piling method of sinking in running ground.

From the nature of such timbering, it must be plain that a shaft piled in this way has necessarily to be sunk in courses, the length of each course depending on the length of pile that can be used, and as it is considered inadvisable to attempt more than three courses, it follows that, if the desired depth is to be reached with these, the piling of each course may require to be of considerable length, and, according to the length, so must the dimensions in other directions of the timber used for the piles be determined. It is claimed that in ground containing few boulders, 4-inch by 10-inch tongued-and-grooved piling can be driven in 16-foot lengths, making a net depth, including necessary overlap, of about 12 feet per course. Piling of 6-inch by 10-inch timber can, however, be driven in lengths of 26 feet, making a net depth of 20 feet per course. For the driving of these long piles a pile-driver such as is used in bridge work is employed, but in some localities a steam-hammer is preferred. The ends of the piles are trimmed to wedge-shape to facilitate easy driving.

FIG. 58.—Methods of preparing sheet-piling.

When one course of piling has been driven to its full depth, and the necessary frame-sets have been put in, a second course is started inside it, enough space being left between the outer sides of the first frame-set of the new course and the inner sides of those in the first course to admit of the piling being entered, and the same procedure is followed with the third course, which is driven inside the second. Owing to the closing in of the area of the shaft with each successive course, it follows that the first must be started of sufficiently

large sectional area to permit of the compulsory decrease in the size of the shaft without reducing the latter in the bottom course to dimensions too limited for the service required of it. The loss of sectional area at each course is about one-fifth.

It is to be noted that only the piling of the first course can be driven in an uninterrupted line around the shaft. Owing to the position of the dividers in this course, it is not possible to drive the piling in the subsequent course in the same close order. To get over this difficulty as far as circumstances permit, specially prepared piles, as shown in fig. 59, are made use of. They do not altogether close the opening, but by using short coping-boards, put in as the sinking progresses, runs of loose ground can be prevented, and water can be held back to a useful degree. One defect of this method of timbering in loose

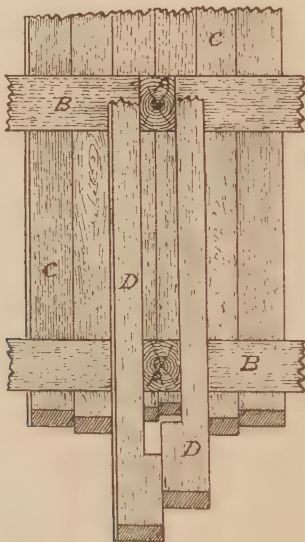


FIG. 59.—Sheet-piling used for special purposes.

ground is that it can only be carried down to a limited depth. By using metal sheet-piling, one shaft in the United States of America was sunk 75 feet, but with wooden piling few shafts of the kind have been carried down much more than 40 feet.

Another method of piling, which is an adaptation of the two just described, is shown in fig. 60. One course is sunk with vertical piling, after which inclined piling, or fore-poling is resorted to. When the first course has been completed, two frame-sets of smaller dimensions are put in at AA, and piles are driven with an outward slant. These piles should be of sufficient length to cover the spacing of two full shaft sets, and when they are driven home their top ends rest against the inner side of the upper set and the outer side of the set next below. Coping-boards are used at the corners, as shown in fig. 54.

Still another variation on the piling methods has been described by Donaldson (29), and is shown in fig. 61. This resembles the method last mentioned, except that, as depth is gained, two or more frame-sets are put in skin to skin to resist the pressure from the running ground which in some localities becomes at a depth of from 40 feet onwards too great to be withstood by a single set. The method can only be adopted as a last resort, say in cases where but a few

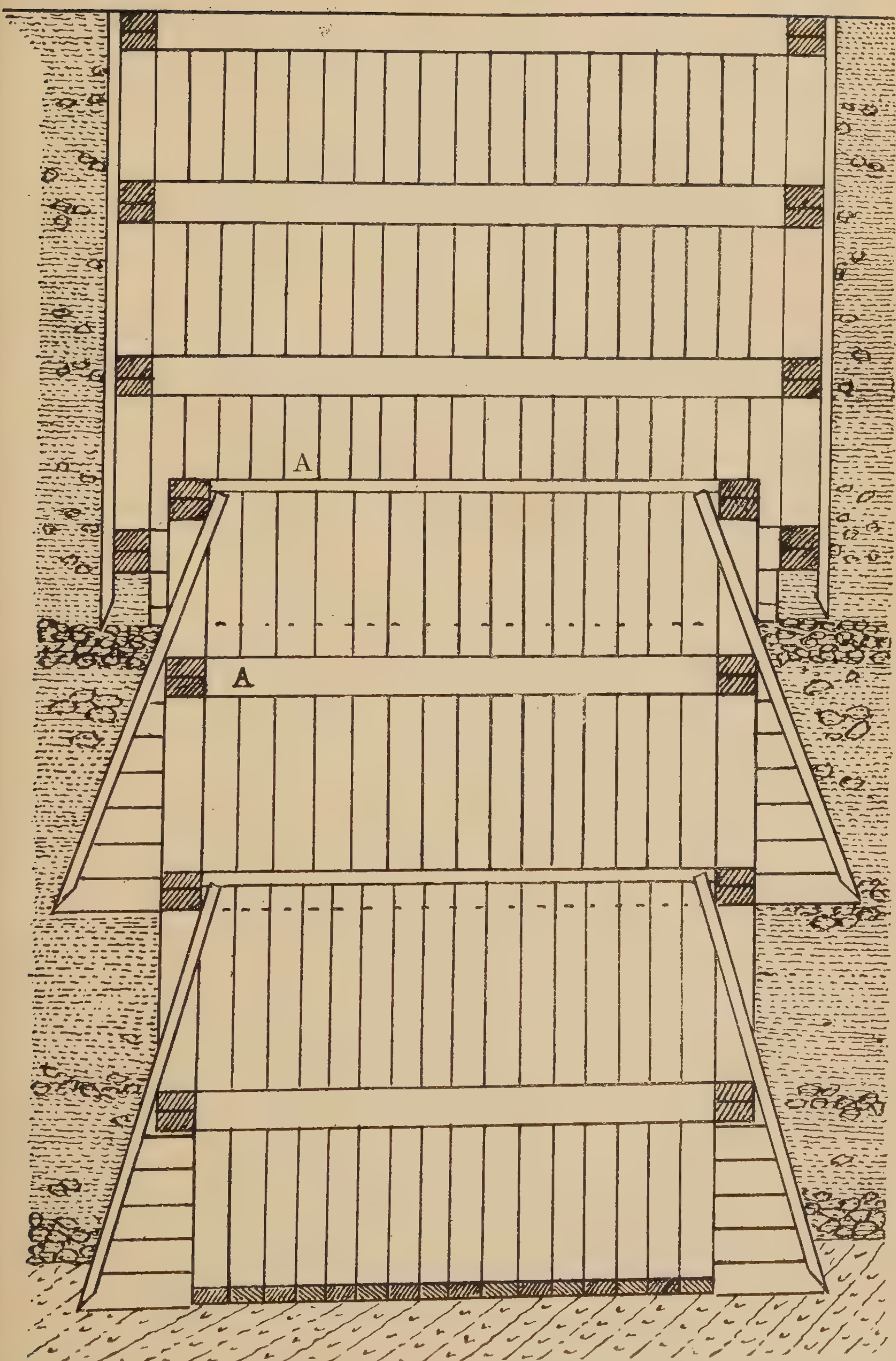


FIG. 60.—Combination of sheet-piling and fore-poling.

feet further sinking has to be completed to reach firm ground, for, apart from

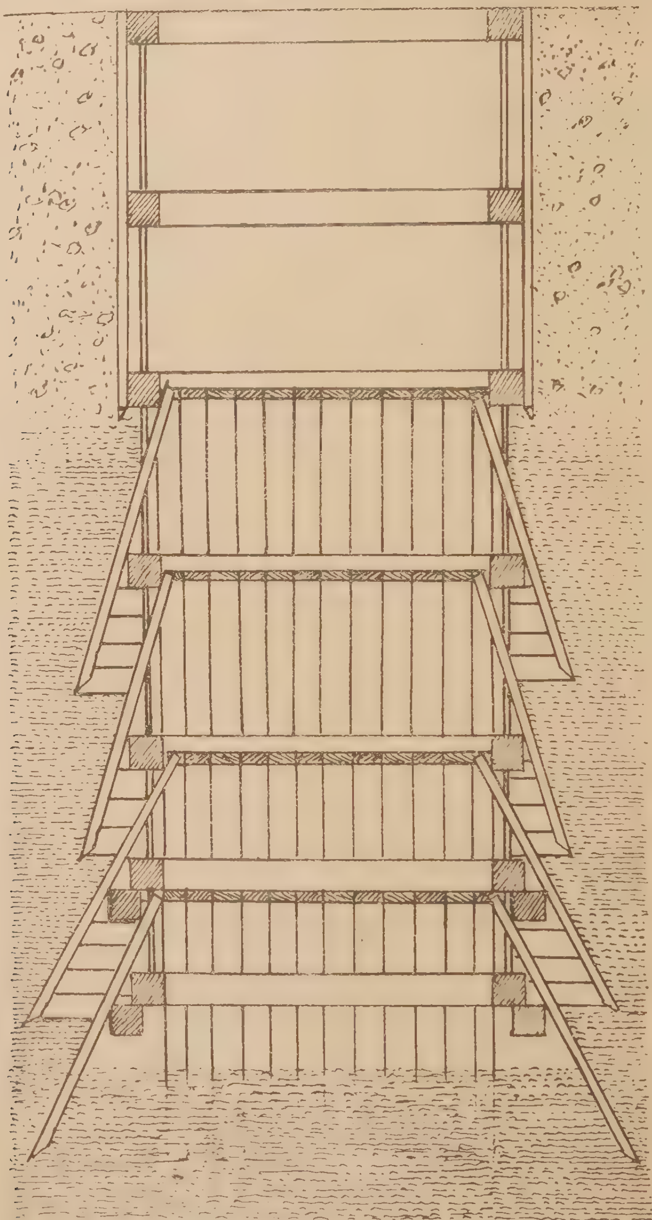


FIG. 61.—Combination of sheet-piling and fore-poling, with extra sets for resisting excessive pressures.

the doubling of the sets making the advancing of the piles a matter of difficulty, the spacing between the sets has usually to be reduced until the piling has to

be driven nearly horizontally, necessitating the opening up of a great extent of shaft bottom, and rendering it impossible to prevent the ground swelling up in it.

If it is merely a matter of holding water back in a shaft, the ground itself

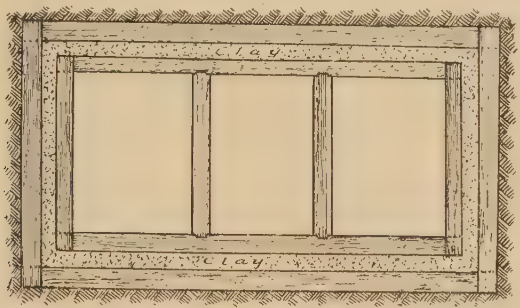


Fig. 62.—Clay packing between double shaft timbers to hold back water.

not being troublesome by reason of excessive looseness, some such method of timbering as shown in fig. 62 may prove satisfactory. An outer shell of box timbering, close fitting, is placed in the shaft, with an inner shell a few inches inside it, and the space between is packed tightly with well-puddled clay. Ihlseng (5) states that a shaft of this kind was carried successfully through quicksand at Taylorville, Indiana, U.S.A. The timber of the outer sets was 12 inches by 12 inches, and of the inner 10 inches by 10 inches, with 4 inches of puddled clay between them. The early alluvial miners of Ballarat, Australia, used a somewhat similar method in penetrating strata of traprock heavily charged with water, several of which had to be passed through in order to reach bottom. To hold the water back, the shafts were opened out on reaching the strata containing it, and sets were put in, as shown in fig. 63, a few inches outside the line of the ordinary shaft boxing. When the water-charged seam had been sunk through, the regular boxing was put in place, and the space between the two linings packed with clay. This method served its purpose well.

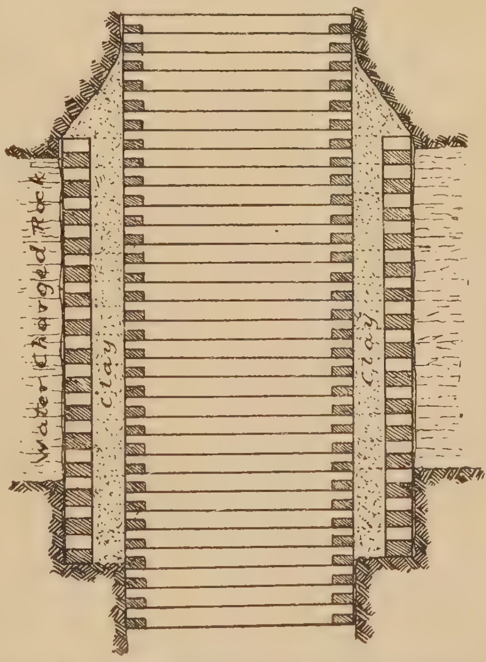


Fig. 63.—Double timbering when passing through water-charged strata.

DROP-SHAFT TIMBERING.

The drop-shaft method of sinking through running ground by using steel caissons is in common use, and most mining men have a general knowledge of it, but it is not so well known that very good work has been done in penetrating ground of this nature by means of wooden caissons. Within quite recent years a timber-lined drop-shaft was sunk through 90 feet of sand and gravel at Woodrow, Cuyuna Iron Range, Minnesota, U.S.A., and a description of it by M'Kay (58) gives a clear account of the procedure followed and the difficulties that had to be overcome. The following *résumé* of M'Kay's paper appeared in *The Mining Magazine*, vol. xxvi. No. 5, and as it cannot be improved on is quoted practically in entirety, such alterations only being made as were necessary to fit in with the text. Figs. 64 to 66 are taken from the paper.

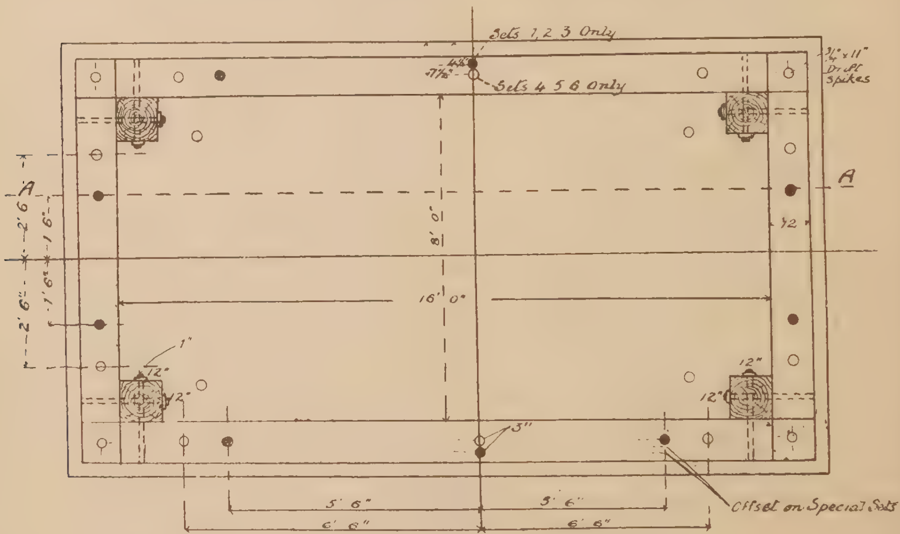


FIG. 64.—Timber drop-shaft (plan).

"The accompanying illustrations show the details of the construction of the lining. This inside lining has an inside measurement of 8 feet by 16 feet. The skin friction on the outside of a drop-lining often becomes so great that it is impossible to get enough weight on to the unexposed portions of the shaft to overcome it. To be prepared for this emergency, the three bottom sets and the shoe were built independently and connected to the balance of the lining by $\frac{3}{4}$-inch by 4-inch strops so constructed that they could be easily cut, allowing the shoe to be forced ahead of the main shaft by means of jacks and wedges. A 6-foot by $\frac{3}{16}$-inch tank steel apron was bolted to sets No. 1, 2, and 3, and extended 3 feet above set No. 3. This apron was for the purpose of keeping the sand back while the shoe was being forced downward, and to give the necessary space to insert sets under set No. 4, as shown in fig. 65. In this particular case it was not necessary to force the shoe ahead or cut the strops, as the shaft dropped below the sand into the altered rock. The shaft was constructed of 12-inch by 12-inch Oregon fir, surfaced. It was made water-tight by placing two ribbons of oakum between each set.

"The lower seven sets were 6 inches wider in dimension than the main part

of the lining. Set No. 8 was 3 inches wider. This gave the lower part of the lining a bell shape. In clay or hard ground this 6-inch space relieved the skin friction, while in cases of sand boils, or runs from the sides, the downward pressure on the bell-shaped section aided in carrying the lining downward. The framing was done on the surface near the shaft site. The shoe and the bell part of the lining, consisting of eight sets, were constructed and bolted together on the surface. The members of each set were tied together with 3-inch by 11-inch drift spikes. The sets were tied together with $1\frac{1}{4}$-inch bolts,

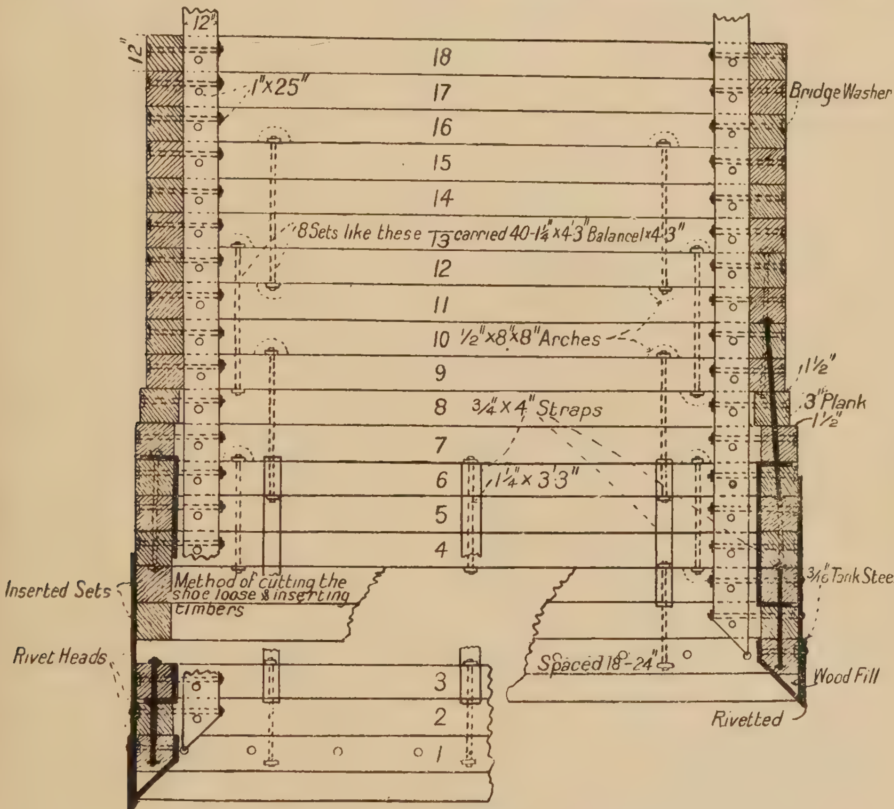


FIG. 65.—Section of timber drop-shaft.

except sets Nos. 3 and 4, which were tied together with $\frac{3}{4}$-inch by 4-inch strops, as shown in fig. 65. The second set of bolts from the bottom were put in after the timbers were in place. This was necessary, as the bolts had to go through the strops and the timber. A hand hole was made in set No. 3 under the bolt so that the nut could be held while being tightened. All other vertical bolts were $1\frac{1}{4}$ inches by 4 feet 3 inches, and were set with head down. The timbers were worked down on the bolts and drawn together with the nuts. The bolts were started every third set, that is six, nine, twelve, etc. By this arrangement each set was bolted to the one above and to the one below. Steel-plate washers $\frac{1}{2}$ inch by 8 inches by 8 inches were used on all vertical bolts. A derrick with an extra long boom, set well back from the shaft site, was used for hoisting. A head-frame was not possible owing to the caving ground near the shaft. When

the shaft was completed the ground within a radius of 30 feet had caved to a depth of 30 feet at the shaft. A hole 12 feet deep was excavated at the shaft site with horse scrapers. The seven completed sets were lowered into the excavation with jacks and skids, five sets more were placed, and the 40-foot vertical corner members placed with the derrick and bolted to the twelve sets. Concrete was poured into the spaces between the corner members, which gave extra stiffness to the shaft.

"At a depth of 16 feet water was encountered and digging was stopped while enough sets were added to place the pumps in safety. The pumps, No. 2 Camerons, bored and bushed, were placed 20 feet above the lower set. Owing to the sand boils it was necessary to have the pumps as high as practicable in the shaft. The pumps had been bushed with phosphor-bronze bushings. This was necessary on account of the extreme wear caused by the sand. When sinking through the fine sand the bushings would last about two weeks, the pumps would have to be packed every hour, and new valves were necessary every day. The end of the suction hose and screen could be raised and lowered by means of rope and blocks. In case of a sand boil, one miner would stand by to keep the hose from getting choked or buried in the sand.

"The pipe lines were carried as shown in fig. 66. The pipe was cut in 10-foot lengths, flanged at both ends and added to the top of the lining as the latter dropped. The variation in height and length was taken care of by a swivel joint made with two L's. The average flow of water was about 300 gallons per minute. One of the pumps could take care of this flow, thus allowing time to add pipes and pack pumps, etc.

"When possible, the miners would dig under the cutting edge of the shoe, but the greater part of the time the sand in the shaft was from 2 feet to 6 feet above the cutting edge, and in very fine sand up to 15 feet above the cutting edge. At such times the sand would be shovelled from the centre when the shaft was dropping vertically, or from the sides when it was desired to start a run from one side or the other in order to bring the lining back into a vertical plane. Small sand-boils could generally be checked by piling cement sacks filled with sand on the boiling area, and by driving oak planks past the shoe. However, the only sure way of stopping sand boils was to have weight enough on the shaft to carry it downward during the boil and thus automatically shut it out. The downward pressure against the projecting shoe during a boil aided materially in carrying the shaft down. During heavy boils the shaft would at times drop as much as 6 inches in a few minutes. The shift foremen and miners watched the plumb-bobs which were kept suspended from the top to see that the shaft did not get out of line or out of a vertical plane.

"The chief sources of weight on the shaft were timbers, bolts, steel pumps, pipe, concrete, and sand. The sand boxes were started at set No 30. The interior sand boxes were 5 feet high by 4 feet wide by 8 feet long, and were continuous to the top. This gave 64 cubic feet of sand to the foot in height. When the shaft was completed there was 60 feet of sand boxes containing 3840 cubic feet of sand. The outside boxes were started when the shaft was down 50 feet. These boxes were generally carried 20 feet high and consisted of four independent boxes, one above the other. When the lining dropped to where the lower boxes touched the ground these boxes were removed and others added at the top to take their place. The outside boxes contained about 5360 cubic feet of sand.

"When the shoe was passing through clay and boulders much trouble was caused by boulders getting under the cutting edge of the shoe. In such cases the cutting edge was generally in sight and the boulders could be worked

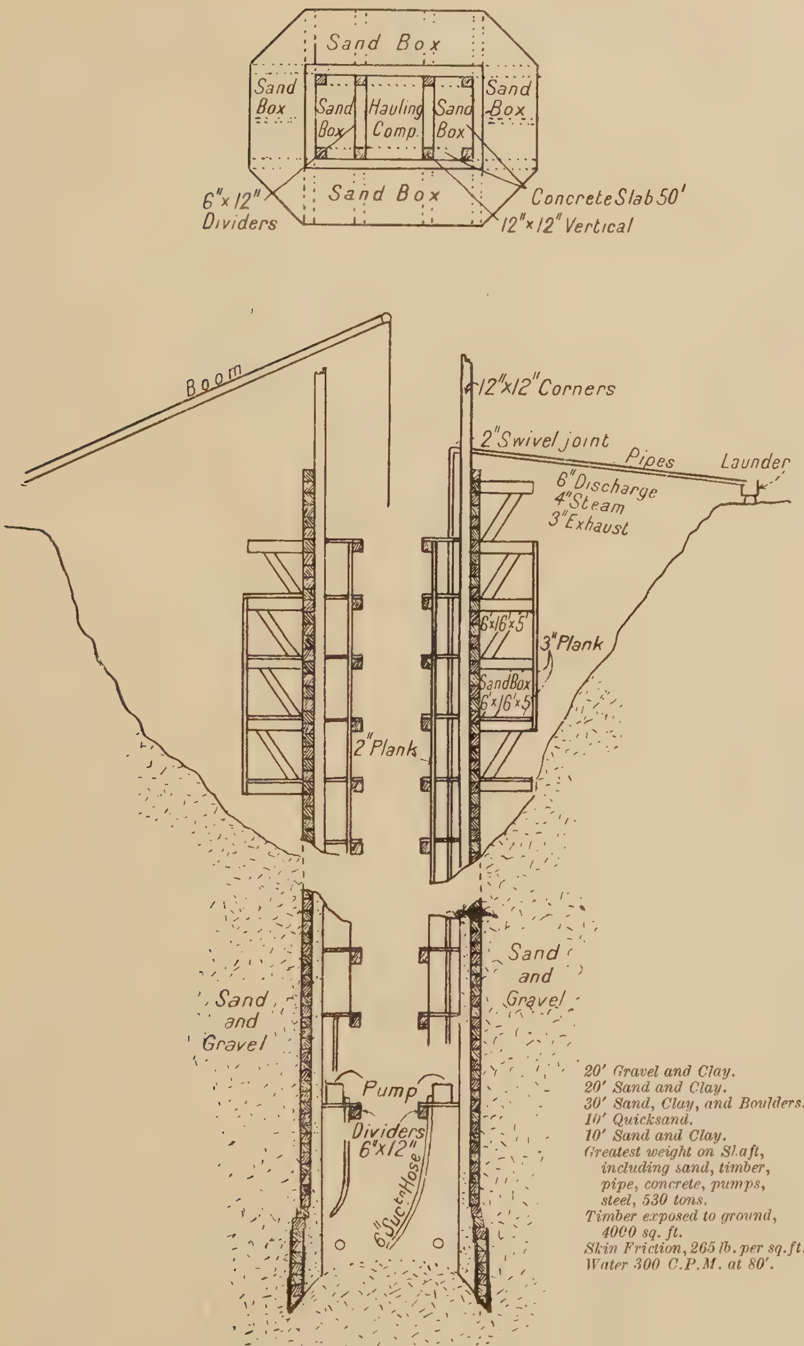


Fig. 66.—Section of timber drop-shaft.

through into the shaft. The largest boulder encountered was 3 feet in diameter. After passing through 70 feet of stratified material, consisting of layers of gravel, clay, sand, boulders, and clay, and sand and clay successively, in beds from 2 feet to 10 feet thick, the lining went through 10 feet of quicksand, 10 feet of fine sand and clay, and 2 feet of altered slate.

"When the shoe was passing through the quicksand the more compact material above settled against the walls of the shaft, causing a heavy drag. The sticky clay increased the skin friction very much. The upper 4 feet of the underlying rock was very soft and had the appearance of soft clay. The altered rock made a very good seal, shutting out all the water and sand. Before the seal could be strengthened with concrete on the inside and outside of the shoe, the sand and water broke through in a small hole about 6 inches in diameter and filled the shaft with sand to within 30 feet of the top, covering the pumps and all the tools. This sand was shovelled out in about four days. The hole under the shoe was found sealed with boulders and clay. The shoe was cemented in and no more trouble encountered. The lining dropped on an average of 1 foot per day. When completed, it had a 9-inch bow in the centre. The lower edge of the shoe was vertically under the top of the shaft.

"The greatest weight on the shaft at any time was 530 tons. The greatest amount of skin friction was approximately 265 lb. per square foot."

TIMBERING CYLINDRICAL SHAFTS.

As previously stated, cylindrical shafts entirely, or even largely, supported by timber are now seldom made use of. The modern mining engineer, when he has to put down a circular shaft, prefers to line it with more enduring material. Timber is, however, still used to a limited extent as a regular method of support in such shafts, and somewhat more frequently as temporary support which is later on replaced by brick or concrete, consequently some brief description of the methods of employing it may be justified. Fig. 67 shows a method described by Le Neve Foster (3) as being followed in a shaft at Borislau in Galicia. In place of horizontal sets of timber, rings of channel iron made in two pieces were used, the halves being joined by special castings which served the same purpose as fish-plates in railway construction. Four bolts were provided at each joint, two on either side of it. The rings were spaced one metre apart, centre to centre, and, when in place, vertical lagging consisting of oak planks was stood outside them. Four posts or studdles of round timber were placed between each pair of rings, and below every second or third ring two oak bearers BB were set across the shaft in hitches. These

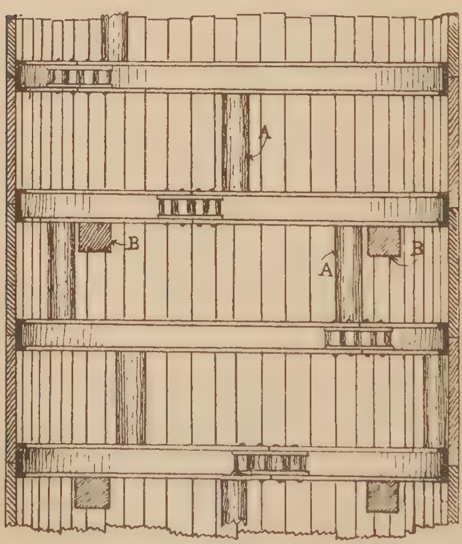


FIG. 67.—Section of timber-lined cylindrical shaft.

served both to support the iron rings and to carry the guides for the cage. The shaft referred to is said to have been kept open in very heavy ground.

In fig. 68 another method is shown in which timber is wholly employed. Instead of channel iron, timber segments *aa* are used to form the rings, each segment being joined to those on either side of it by nailing wooden cleats *dd* at top and bottom. On the upper cleats, the posts *bb* are stood, and the rings are hung one from another by boards *cc*. Outside the rings, vertical lagging, *ee*, is placed. Timbering of this kind could not be expected to withstand any great pressures, and is only used as a temporary provision.

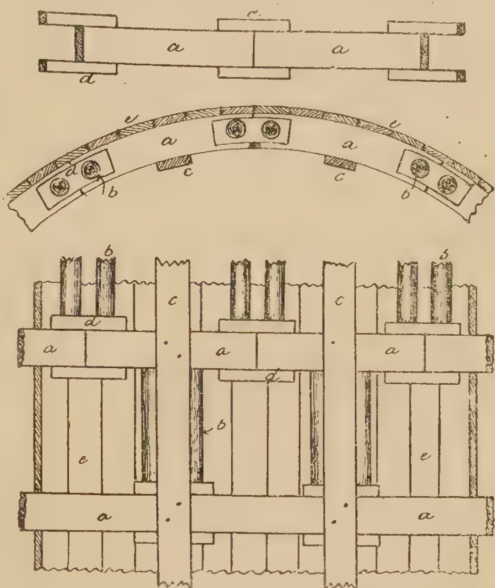


FIG. 68.—Timbered cylindrical shaft.

Further methods used more or less for lining such shafts with timber are those known as plank tubbing and solid timber tubbing. The first consists in arranging planking 2 inches to 3 inches thick around in the same manner as staves in a barrel, the planks being nailed to wooden rings placed at suitable intervals. Solid timber tubbing consists in lining the shaft with blocks of timber prepared and set like masonry. Sheets of deal are placed in each joint, and all the joints are wedged up as tightly as possible. Le Neve Foster (3) states that lining of this kind can be made to resist a very considerable pressure of water, say 200 lb. to 300 lb. per square inch.

LADDERS AND LADDER-WAYS.

Up till very recent years it was not uncommon to see the ladders in a vertical shaft placed one above the other directly, either against the side or across a corner of the compartment. In all modern shafts the ladders are stood in a leaning position, and stagings are provided at short intervals. An ordinary length for a ladder in present-day practice would be about 20 feet, and as from 2 feet to 3 feet of it is allowed to project above the stagings, it follows that the latter are about 17 feet apart. This distance is often exceeded, ladders up to 30 feet in length being preferred on some mining fields. The prevailing rule is to space stagings about 18 feet to 20 feet apart.

The manner of arranging the ladders that is now most generally followed is shown in fig. 69, a good stage being provided at each change so that workmen may pass in safety from one ladder to another. The stagings consist of strong timber resting on the frame-sets, or, in the case of a boxed shaft, on the wall-plates.

Occasionally in a boxed shaft the staging planks are merely secured by having cleats nailed to the wall-plates beneath them. The practice of fixing stages in this way is not to be commended, for nails are readily corroded by

mine water. The writer is familiar with one instance where 150 feet of ladders which had been stood upon stagings set upon cleats secured in this way collapsed after having been in place only a little over a year. Occasionally, also, cases are noted from time to time when, instead of the ladders being placed as shown in fig. 69, they are set as in fig. 70. This method of standing them should be avoided, if for no other reason that a workman ascending or descending is compelled to turn right-about at each change, and as the stage-room in which he had to do this is limited, there is always the element of danger present. A man proceeding downward is also likely to step into the opening giving access to the next ladder below. In cases where a ladder does not project above the staging, iron dogs should be driven into the shaft timber to afford hand-grips.

Material used for Ladders.—The material used for the sides of ladders varies with each mining field, the most suitable local timber being usually

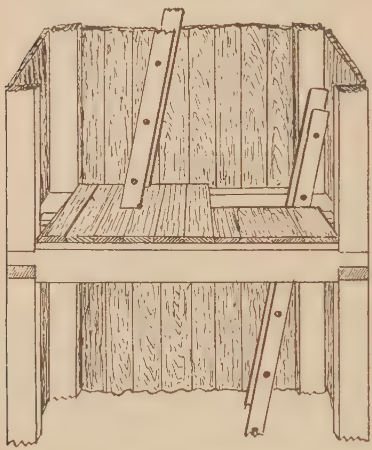


Fig. 69.—Correct arrangement of shaft ladders.

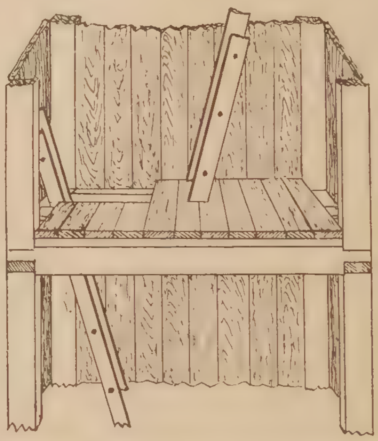


Fig. 70.—Incorrect arrangement of shaft ladders.

employed. Timber of a brittle nature, or subject to rapid decay, should be avoided. When hardwood is available it is used by preference as giving longer and better service than most soft woods. The size of timber used is generally 4 inches by 2 inches or $2\frac{1}{2}$ inches. The ladder is made from 10 inches to 12 inches wide between the sides, and the rungs are spaced from 10-inch to 12-inch centres, the former being the most suitable distance. The rungs may be either of wood or iron, but for shaft work iron is by far the better material. Round bar iron of $\frac{3}{4}$ inch diameter is mostly used. The rungs do not pass through the sides of the ladder, but are let into them as in fig. 71 (A) to a depth of 1 inch in holes bored for the purpose. Every fifth or sixth rung is made longer than the others, and is converted into a bolt which passes through the sides, and holds the ladder together. A somewhat similar ladder is made by using pieces of $\frac{3}{4}$-inch piping, as at B (fig. 71), a bolt being passed through an occasional rung and the ladder sides.

In some mines the water has so powerful an action on iron that it is scarcely safe to use it for ladder rungs. Under such circumstances, wooden rungs may be used, but, in a general way, it may be questioned if it is not best under all conditions to use iron, even if the ladders have to be renewed frequently. In any case, if wooden rungs are used in a shaft ladder, they should be set as

at C (fig. 71), no nails being used in securing them. To keep the rungs from turning, wedges are driven into them at each end. The wedges are usually

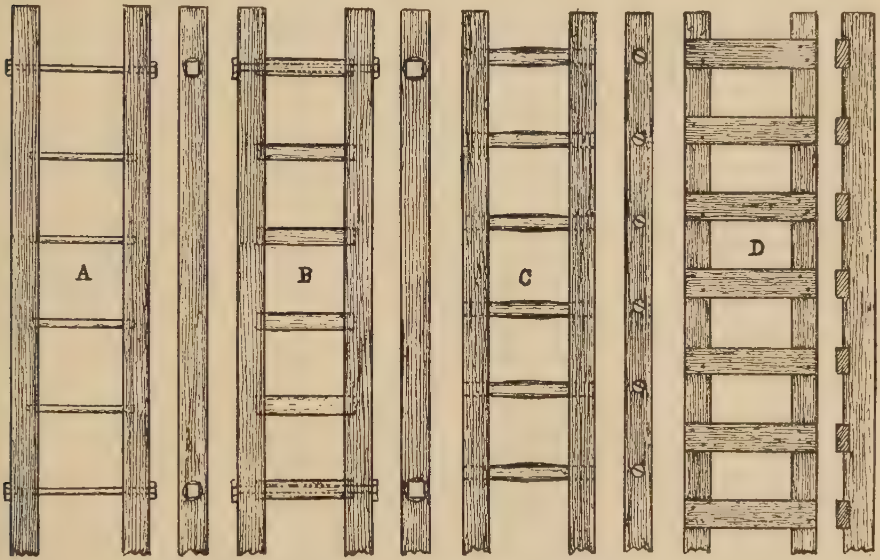


FIG. 71.—Types of ladders used in shafts.

made of wood. The ladder shown at D (fig. 71) is only suitable for shallow shafts, or in cases when the mine water contains no acids.

SKIDS OR GUIDES.

In some of the more modern shafts, where very rapid winding is called for, wire ropes are used to guide the cages, but in the majority of haulage shafts the practice of using wooden guides is still followed. In a small shaft only two guides are placed in each haulage compartment, but in large shafts there may be as many as six. In any case, one pair of guides are invariably fixed to the end-plates or dividers at a point equidistant from the wall-plates. In a wide shaft two further pairs are placed near the sides and about 6 inches from the wall-plates. The central guides engage with shoes or runners on the cage, but those near the sides merely serve as buffers, preventing undue swaying of the long cage, and keeping it square in the shaft. The arrangement of the six guides in a large shaft is shown in fig. 72. The guides near the wall-plates are usually of

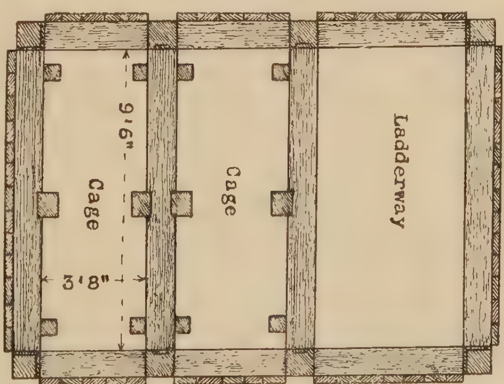


FIG. 72.—Arrangement of guides in a wide shaft.

smaller dimensions than the central ones. The size of timber used varies considerably, but may be said to range from 4 inches by 4 inches to 8 inches by 6 inches. In shafts of moderate size, say with haulage compartments up to 4 feet by 4 feet 6 inches, the 4-inch by 4-inch guide is in common use, and where the shafts are not deep and high speed in winding is not necessary this size meets requirements very satisfactorily. Even in such small shafts, however, it is advantageous to use a somewhat larger guide, say of 6-inch by 4-inch timber, for the wider bearing surface offered to the cage-runner ensures smoother travel of the cage, with consequently less vibration, and less wear and tear on the guides themselves. On the Reefton field, New Zealand, where the haulage compartments of the various shafts are all about the dimensions mentioned, the use of 4-inch by 4-inch guides was general, but it was found that as depth was gained the wear and tear on the guides became excessive, and there was constant breaking of coach-screws owing to the swaying of the cages. In such shafts as the Blackwater (1675 feet) and the Big River (1925 feet), the guides were increased in size to 8 inches by 4 inches, by spiking 4-inch by 2-inch scantlings on each side of the original guides, with the result that little further trouble was experienced. In larger shafts, the invariable rule is to put in larger guides, say of 8 inches by 6 inches, from the start, with, when necessary, extra side runners to keep the travel of the cages steady.

The length of guides varies from about 16 feet to 24 feet. In boxed shafts any suitable length within these limits may be adopted, but in frame-set shafts it is usual to cut the guides of such length that they join in the centre of an end-plate or divider, and may thus be, according to the distance apart the sets are spaced, long enough to touch either three or four sets. Guides shorter than about 16 feet are not often used.

Timber used for Guides.—A number of different varieties of timber are, according to locality, used for the making of cage guides. As a rule very hard woods are avoided. In some parts of Australia, jarrah is used, and in New Zealand, kauri and rimu. Throughout American mining fields, Oregon is almost exclusively preferred, and so serviceable has this timber proved for the purpose that even in Australia it is now extensively employed. The reasons for not using very hard timbers are, firstly, their great weight, which makes them difficult to handle, especially in repair work, and, secondly, the fact that the safety-grips of the cage do not take hold on them, particularly if they are well-seasoned, as rapidly or effectively as they do on timber of slightly softer nature. Further, many of the hardwoods, although possessing very lasting qualities when the question is merely one of wear, are of short grain, and easily snapped by a sudden jar. Oregon wears rapidly, but is very elastic, and has a long, tough fibre that makes it difficult to break. It is neither too hard to prevent the safety-grips securing ready hold in case of a cage escaping, nor soft as to allow them to cut through or split the guide. It is also light compared with other timbers, and this is a consideration both in handling it underground and in transporting it to the mine.

Whatever variety of timber is used, the practice is to plane the three exposed sides to lessen friction as much as possible. In the case of auxiliary guides or runners, it is only necessary to dress them on the side coming in contact with the cage.

Securing Guides.—The most general practice is to fasten the guides to the end-plates or dividers by means of coach-screws. Care is taken to see that they are in proper alignment. A plumb-line hung from the guides above may be used for this purpose, but most timbermen use a gauge or template from which they mark off the exact position the guide is to occupy.

In making the joint between two succeeding lengths of guide, a simple butting up of the timbers one against the other, as at B (fig. 73), is sometimes preferred, but the more common practice is to provide tongues or tenons, with corresponding mortices, as at A and C. In case of a coach-screw breaking—a very frequent occurrence in a shaft—these tongues materially help in keeping the guide in place till a fresh screw can be put in. Without them, the guide would probably move to one side or the other, with the result that the shoe of the cage would catch it and tear it completely away, with the danger of serious damage being done to the shaft and winding gear.

As previously mentioned, it is customary in a frame-set shaft to joint the guides on a divider or end-plate, but the practice is not scrupulously followed. Occasionally the joint is made between the shaft sets, in which case a plate of $\frac{1}{2}$-inch wrought iron is placed behind the ends of the two pieces of timber, as at D (fig. 73), and securely bolted to them, the bolts being countersunk so that their heads cannot catch against any part of the cage. This method of making the joint has little to recommend it, for the vibration attendant on the rapid

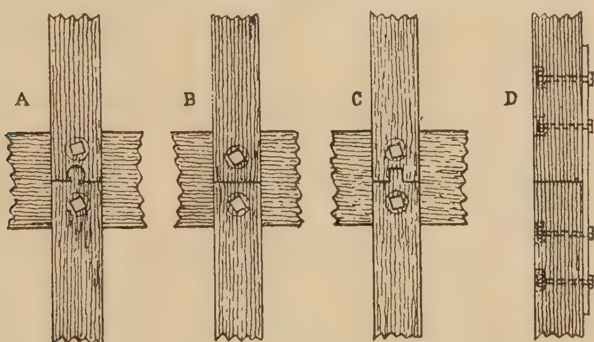


FIG. 73.—Methods of making guide joints.

winding of the cage is at all times considerable, and joints of this kind seldom withstand it for any great length of time, the guide tending to split along the line of the bolt holes. Danger of breaking the joint may be lessened by standing a further post in the set between the dividers and behind the guide, but even the taking of this precaution will not ensure that the joint will have that rigidity it is essential it should have.

In the case of a boxed shaft, coach-screws are put in the guide at about every 4 feet to 5 feet. In a frame-set shaft the screws are inserted at each set. For guides 4 inches deep, $\frac{5}{8}$-inch to $\frac{3}{4}$-inch screws are used, their length being about 7 inches. Before the screw is put in, a hole is first bored with a counter-sinking auger, as shown in fig. 74, to a depth of about $1\frac{1}{8}$ inches, after which the remainder of the hole is bored partly with a $\frac{5}{8}$-inch or $\frac{3}{4}$-inch auger (according to the size of screw used), and partly with a $\frac{1}{2}$-inch to $\frac{3}{8}$-inch auger. The screw is then inserted, and is usually driven part of the way with a hammer, and screwed the remainder with a box-spanner. Although so commonly adopted, the practice of securing guides by means of coach-screws is one to which many objections can be made. In the first place, coach-screws are very easily broken. Even when they are being screwed in for the first time they not infrequently snap off in the wood, and they are broken in numbers by the jarring resulting from the winding of the cages. In nearly all mines where much haulage of materials is done it is necessary for men frequently to carry

out the task known as "going through the shaft," that is, the making of a systematic examination of all parts of it in order to note any defects that may have revealed themselves, and one of the most important duties these men have to attend to is the detection and replacement of broken screws in the guides. So great an evil does this breaking of screws become in some shafts that after a short time the end-plates and dividers are so full of broken-off screw-ends,

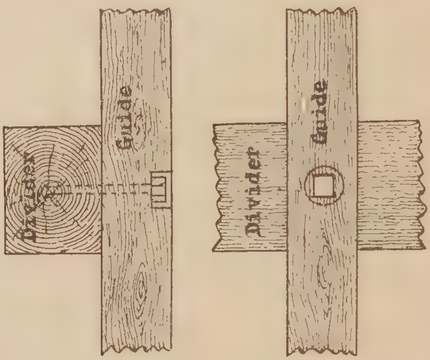


FIG. 74.—Coach-screw method of attaching guide to divider.

which cannot be removed, that it is difficult to find a place to insert a new screw. This applies more particularly to frame-set shafts, and to get over the difficulty one custom followed is to spike a fresh piece of timber, as in fig. 75, on top of the end-plate, or divider, and secure the guide to this. On the other hand, it has been found at times that, owing to the shrinkage of the timber used, the screws are so tightly gripped that even when it is necessary to remove them

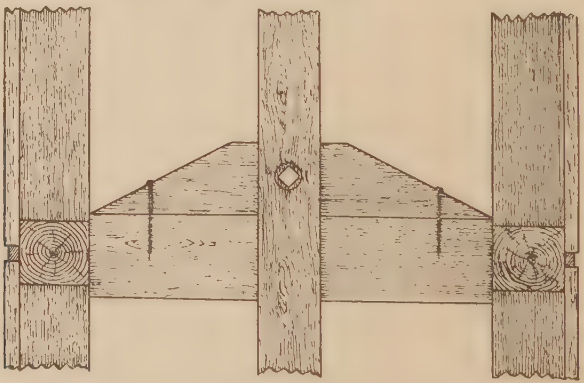


FIG. 75.—Securing fresh hold for coach-screw.

this can only be done with the greatest difficulty. To overcome these disadvantages a number of expedients have been resorted to. With a view to preventing breaking of the coach-screws as much as possible, one method of securing the guides which has been adopted in some mines with success is that shown in fig. 76. This consists in setting the guides back in dovetail slots cut in the end-plates and dividers, and driving wedges at either side of them. In the illustration the guide is 4 inches by 4 inches. The slot in the divider is 7 inches wide at the face, and 8 inches at the back, and is $\frac{7}{8}$ inch deep. The

guide, when being put in, is aligned and coach-screwed in the usual way. Wedges about 18 inches long, $\frac{7}{8}$ inch thick, and tapering from $2\frac{1}{2}$ inches at the top to $1\frac{1}{2}$ inches at the bottom, bevelled to fit the dovetail, are driven down at either side. In actual work, it has been found that wedges placed in this way take up practically all the strain caused by vibration, and, consequently, greatly lessen the tendency of the coach-screws to break.

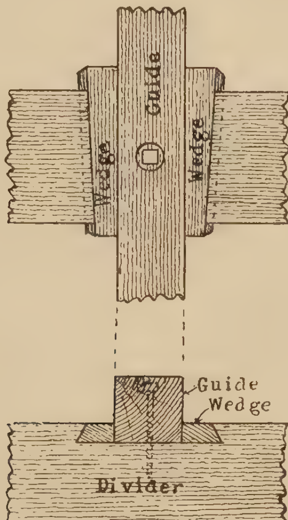


FIG. 76.—Securing guides by means of tapered wedges.

Another method adopted to get over the screw-breaking trouble is that of bolting the guides through and through to the dividers, as in fig. 77, and spiking them to the end-plates. Cleland (1) mentions that in Western Australia this method of securing them has been found much better practice than that of merely coach-screwing the timbers on in the ordinary way. One objection to this method is that if one of the guides on the divider side of the compartment

FIG. 77.—Method of bolting guides to dividers.

has for any reason to be removed, it is necessary to loosen up a guide in the next compartment also, and so men have to be employed in both compartments, an arrangement which, besides being inconvenient, materially increases the cost of repairs.

To avoid the necessity of having to free a guide in each compartment in this way when one of them has to be replaced, whilst at the same time using bolts instead of coach-screws, a method has been introduced of fixing cast-iron brackets to the shaft sets, and securing the guides to them. Various designs

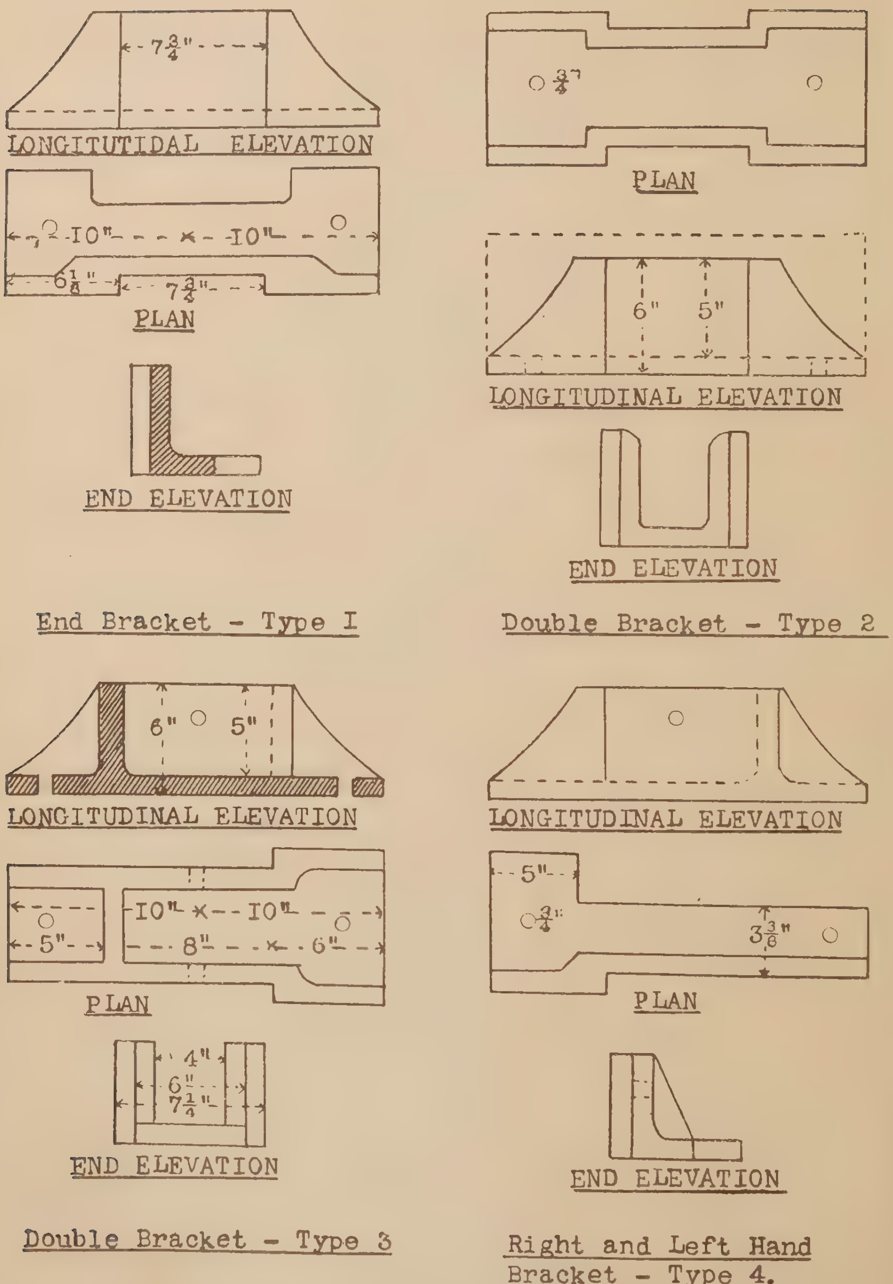


Fig. 78.—Cast-iron brackets for securing guides.

of these brackets are in use, but they need not all be dealt with here. A description of those used in the Kintore shaft at Broken Hill, N.S.W., Australia, taken from a paper by Roberts (28), will sufficiently illustrate their general construction. The methods of attaching them to the guides and dividers are shown in figs. 79 to 82. At a divider where no jointing of guides is made, a bracket is only needed on the top, as in figs. 79 and 80, but at dividers where

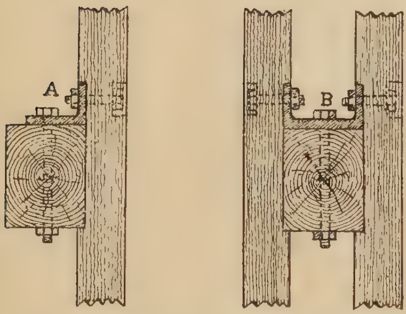


FIG. 79.—Method of securing guide to brackets at dividers where no joint occurs.

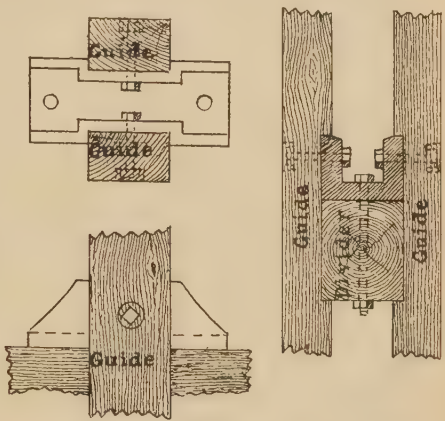


FIG. 80.—Showing further details of brackets.

such joints come it is necessary to use the brackets in pairs, one above and the other below the cross-timber, as in fig. 81. At A (fig. 79) a single bracket is shown. This type is used at the end of the shaft, and at the divider separating the haulage compartment from the ladder-way.

The exact dimensions of the brackets are determined by the size of timber

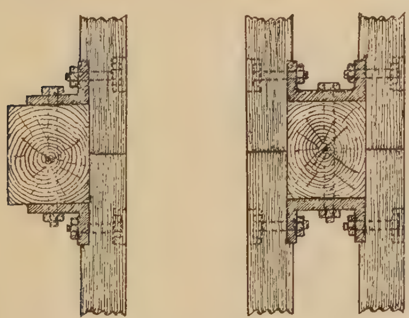


FIG. 81.—Use of double brackets at dividers where guides meet.

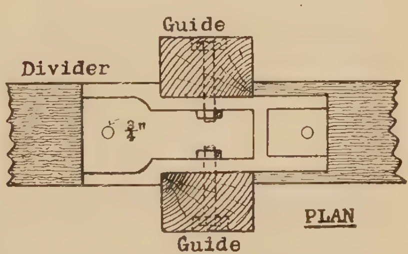


FIG. 82.—Double bracket designed for use in old shafts without disturbing existing arrangements.

used in the guides and frame-sets. In the figs. the dividers are 8 inches by 11 inches, and the guides 8 inches by 5 inches. It will be noted that in fig. 78 the brackets shown in Types 1 and 2 are provided with shoulders to secure the guides on both sides. It may not always be convenient to use brackets of this kind. For instance, if it was desired to put brackets in a shaft that had already been fitted with guides in the ordinary way, at least one guide in each of two

adjoining compartments would have to be removed in order to get the bracket in place. To avoid the necessity of this, brackets having only one shoulder for each guide, as shown in figs. 78 and 82, are employed. If these types are used, the brackets should be reversed in position at each succeeding divider so that at one frame-set the shoulder will be at one side of the guide, and at the next one on the other side. The bolts used are of $\frac{3}{4}$-inch iron, and their heads are countersunk in the same way as when coach-screws are used.

Locating and Aligning Guides.—When the rock broken in sinking a shaft is hauled direct to the surface, and a cross-head is used, the general practice is to put the guides in place as the work progresses, but if the sinking is carried out under a penthouse they are not put in till the full lift has been completed and the penthouse has been removed. The work of attaching the guides is then usually started from the bottom and carried upwards. In a frame-set shaft, the timbermen perform their work from stagings placed across the sets at suitable intervals. The guides are dressed on the surface, cut to length, countersunk and bored for the coach-screws. If the work of putting them in place is being done from the surface, they are sent down, as required, in pairs, and at once secured in their places; but in other cases they are lowered to the plat next above and from there taken as required. In the actual fixing, the bottom coach-screw is usually put in first and screwed up, then the top screw, and finally the intermediate screws, the timberman using a gauge to give the guide its right location. If the guide is warped, as is sometimes the case, the best plan is to put in the bottom screw first, then follow up and insert the other screws at their succeeding locations, the guide being thus forced gradually into correct line from one end to the other.

TIMBERING A RISED SHAFT.

Instead of sinking a shaft directly from surface, or downward from level to level, the method of excavating it in an upward direction is at times adopted. This is known as "raising" or "rising" a shaft, and some have been constructed for considerable distances in this way. If the rising is done in hard ground, the timbering of the shaft to its full size may be carried out as the work progresses, the only difference in the placing of the timber being that the sets are stood one on top of the other instead of being hung as when sinking. In figs. 83 and 84 the way in which a three-compartment shaft of this kind was risen and timbered at the Armenia Mine, Lake Superior district, U.S.A., as described by Goodney (44) is shown, and may be taken as representing the usual procedure. In starting the work, a winze was first sunk from which a drive was put out to the shaft position. A room or chamber was then opened out to the full size of the shaft, and a rising cut taken out up to a height of about 6 feet. Hitches were then cut, and the bearers AA put in and the level set placed on them, and covered with lagging. The ground above was then blasted out and room made for the plat-sets, which were then erected, following which the chamber itself was partially excavated. Rising was then resumed and carried on in the usual way. Prior to putting in a set of timber the whole area of the shaft was bored out and blasted, after which a second round was bored, the cut holes only of which were fired. When the ground had been trimmed

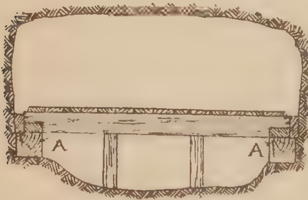


Fig. 83.—Starting to rise a shaft in hard ground.

out after the firing of these cut-holes, the set was stood and lagged over, the remaining holes fired, another round drilled, and so on. The chute for removal of the rock broken during the rising was placed in the centre compartment, and was formed by spiking planking on the inside of the dividers, the planking being extended up to the second set from the top. The opening between the two top sets was left to ensure good ventilation. One of the end compartments was used as an airway, and the other as a ladder-way and for hoisting tools, etc. The top set was protected during blasting operations by laying slabs of 6-inch by 8-inch timber over the plates and dividers, and covering these over in turn, as shown in fig. 84, with round timbers of 10 inches to 12 inches diameter. In the centre a space of about 2 feet in width was left open for the broken rock to fall through into the chute. Only sufficient broken rock was removed from the chute at any time to leave room for that resulting from the next blast.

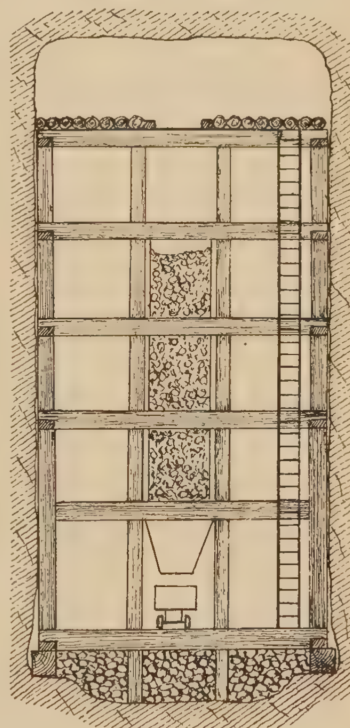


Fig. 84.—Method of timbering when rising a shaft in hard ground.

A boxed shaft would be carried up in much the same way, the centre compartment being used as a rock chute, and the others left open to afford circulation for the ventilating current.

Another method of constructing a shaft by rising is that of taking a small rise through first and opening this out later from the top downward to the full size required. Fig. 85 shows the plan of the original rise and of the completed shaft of a working put through in this way for a height of 621 feet at the Rolling Mill Mine, Negaunee, Michigan, U.S.A., as described by Cory (48) and Donaldson (57). In this case a chamber A (fig. 86) was first cut, and the rise started 8 feet by 8 feet, divided into three compartments. Two of these compartments were formed by cribbing, each compartment being 4 feet by 4 feet, including timber. One of the compartments was used as a ladder-way, etc., and the other for hoisting tools, timber, etc. The other part of the rise, 8 feet by 4 feet, served the purpose of a rock chute, and was not timbered. In drilling out the back of the rise the cut was taken over the rock chute, with the result that the greatest force of the blasting was directed straight down into the chute and not on to the timber, and the remaining holes when fired threw in the same direction, so that the cribbing suffered little damage from this cause. Before any firing of blasts was done, the two compartments of the cribbed portion of the rise were covered, as shown in figs. 86 and 87, by placing timbers at an angle to deflect the falling rock into the rock chute. This timber also afforded the necessary protection to the men when getting away from shots or ascending after blasting operations. To enable the man doing the firing to escape readily, one plank was left off till the last moment, the workman drawing it into place after he had lit the fuses and passed through the opening.

At every 200 feet hitches were cut in the walls and bearers put in, their purpose being to take up the weight of the next 200 feet of timber, instead of letting the whole weight come on the station sets. At every 200 feet also,

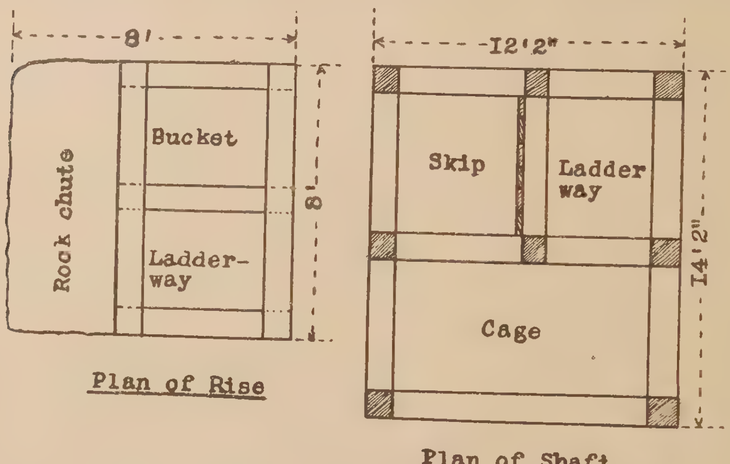


FIG. 85.—Method of rising a shaft by putting up a small timbered rise first, and later enlarging it to full shaft size.

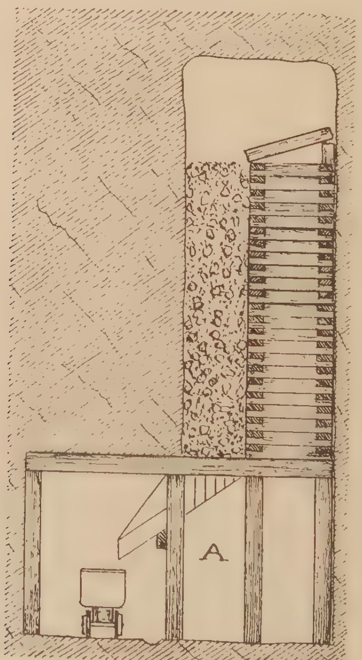


FIG. 86.—Cross-section showing small initial rise, Rolling Mill Mine, Michigan.

small drives were run in to a depth of about 15 feet, to afford further shelter for the men when blasting, and obviate the necessity for them to travel the whole distance to the bottom drive on each occasion.

When the surface had been reached in this way the work of enlarging the shaft was begun. This consisted in first putting in place a brace-set, formed of stringers 30 inches in diameter and 25 feet long, then shooting out the sides of the rise and hanging frame-sets in the usual way (see fig. 88). The progress of the work is stated to have been as follows: rising 621 feet; number of days, 125; average progress per day, 5 feet; cutting down 621 feet; number

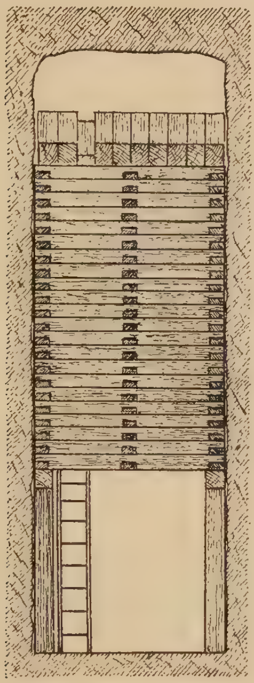


FIG. 87.—Longitudinal section of small initial rise, Rolling Mill Mine.

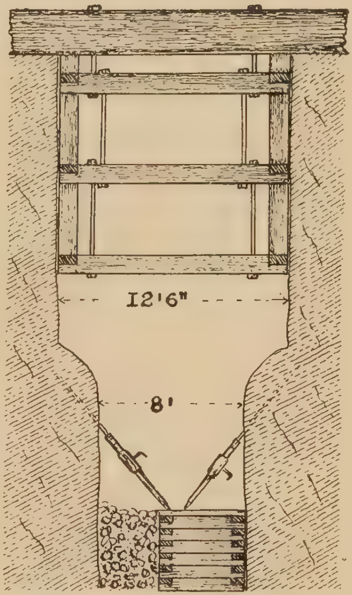


FIG. 88.—Showing method of enlarging rise to full shaft size.

of days, 114; average per day, 5·44 feet; number of men employed, 9, in three shifts of three men each. These men did all the timbering, and trucked the broken rock a distance of 750 feet. No accidents or delays occurred. In stripping the shaft, telescope drills were used. The rock was drawn off, during the enlarging operations, until it had been lowered 15 feet. The timber of the rise was then pulled out for the same distance, and the two compartments covered in the usual way. Holes were then drilled upward around the shaft at an angle of 45 degrees and were started 10 feet below the shaft collar (or such timber as had been put in), and so located as to strip 5 feet of the shaft at one blast, thus making room for a complete set of timber.

CHAPTER II.

INCLINED SHAFTS.

Any shaft deviating from the vertical is here referred to as inclined.

In timbering this kind of shaft much the same methods are followed as in the case of the vertical shaft, except that the class of timbering known as boxing is rarely used, and then only in shafts that very closely approach the vertical in inclination. The various members forming a set are, however, differently named, one of the wall-plates becoming a "cap" and the other a "sill." The end-plates become posts, and the pieces corresponding to posts in a vertical shaft are termed "stays" or "distance pieces." The shaft may be separated into any required number of compartments by dividers.

SMALL INCLINED PROSPECTING SHAFTS.

In small one- or two-compartment prospecting shafts, such as are frequently put down to follow the dip of a lode or vein, very simple methods of supporting the walls may be followed. If round timber is available, it is

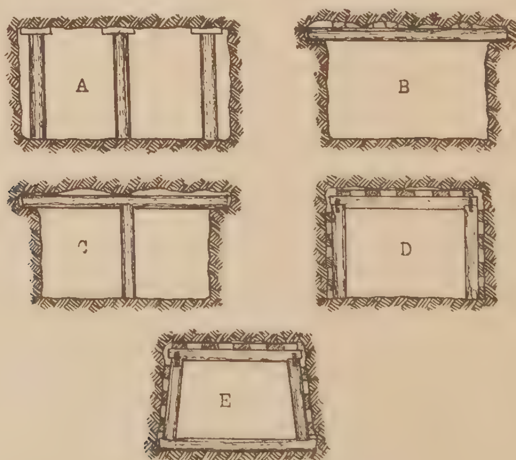


Fig. 89.—Simple methods of timbering flat inclines.

commonly used, and as the work is generally of a temporary character it need not be of large diameter. A number of ways of timbering workings of this kind are shown in fig. 89, all of which are applicable to flat inclines. At D and E in the figure the timbering consists merely of three- or four-piece sets identical with those used in driving, the sets being stayed from one another

in such a way that the post and cap of each set are caught. Timber of this kind is only necessary when the roof and sides are weak. When the sides are strong, but the roof (hanging-wall) has a tendency to flake, the methods shown at A, B, and C may be adopted. Method A consists in the erection of rows of props set across the opening at a right angle to the walls, and tightened against the hanging-wall by means of head-boards and wedges. Method B consists in setting strong beams in hitches in the sides (ends) of the shaft, just under the hanging-wall, and lagging them over ; while method C is similar except that a *tom* or *soldier* is placed under the horizontal beam to give it greater strength.

A variation on the ordinary round timber three-piece set for inclines is

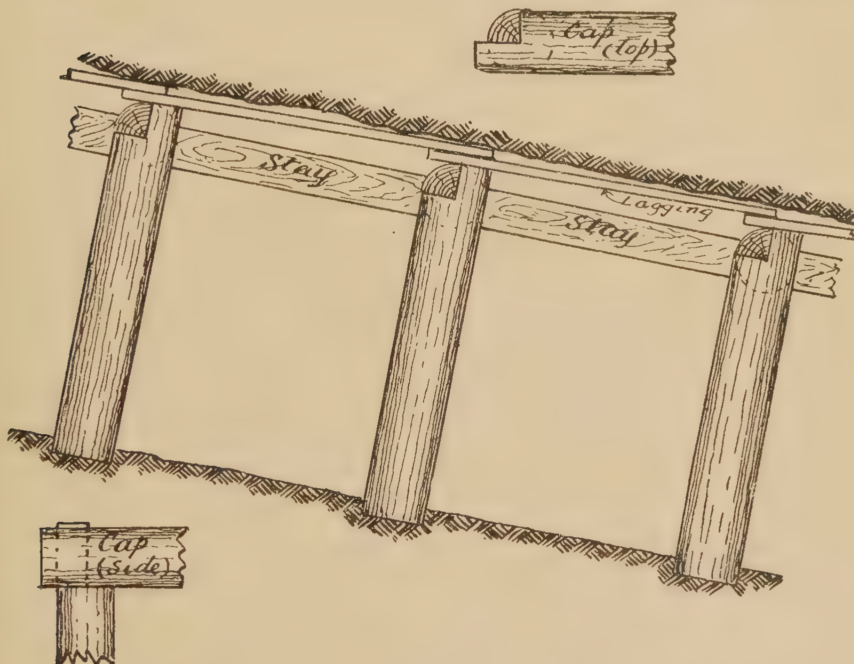


FIG. 90.—Timbering with horn-sets in a flat incline.

that shown in fig. 90. This is known as the horn set, a spill or horn being left on the top of each leg or post. The horn is equal to a quarter of the cross-section of the timber used, and the idea in leaving it on is that it may prevent the cap being knocked back by flying debris from blasting operations. This type of set has no feature warranting its use being recommended in preference to the ordinary set, for if the latter is properly wedged and stayed it is little liable to be shot out of place.

When sawn timber is used for these small shafts, the usual practice is to stand the sets perpendicularly to the cap, and at a right angle to the dip of the working, and they are, as a rule, placed upon sills, as in fig. 91. Whatever may be the method of timbering followed, it is essential that the sets should be placed in such a position that they afford the greatest amount of effective support to the hanging-wall, and this position is as directly at a right angle to it as possible. The sills serve the additional purpose of sleepers for the

skip-road. A joggle or dap about 1 inch deep is provided in both cap and sill to prevent pressure from the ends moving the posts inwards. The stays

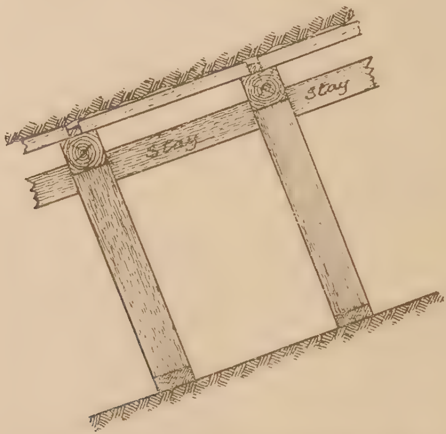


FIG. 91.—Timbering a flat incline with four-piece sets.

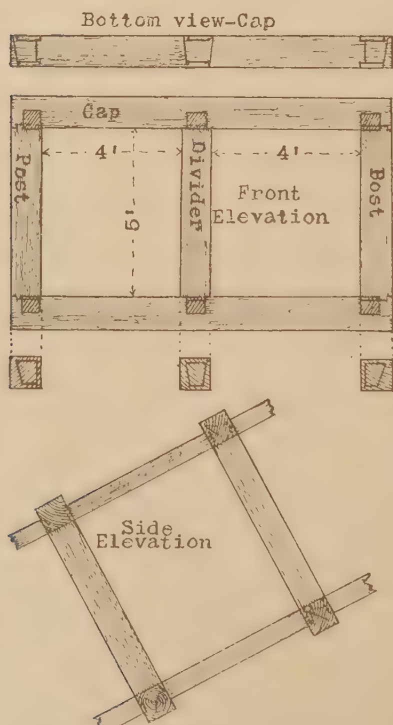


FIG. 92.—Timber for small two-compartment inclined shaft.

between the sets are drift-nailed to the latter, or let into housings prepared for them, as shown in fig. 92.

INCLINED SHAFTS OF THREE OR MORE COMPARTMENTS.

When an inclined shaft is intended for deep working, or to serve a more important purpose than merely prospecting, more elaborate methods of timbering are employed. Shafts of this kind are sometimes sunk in the lode they are intended to develop, but are more commonly put down in the foot-wall country close to the lode. As in the case of the vertical shaft, the most generally adopted design is the three-compartment one, two of the compart-

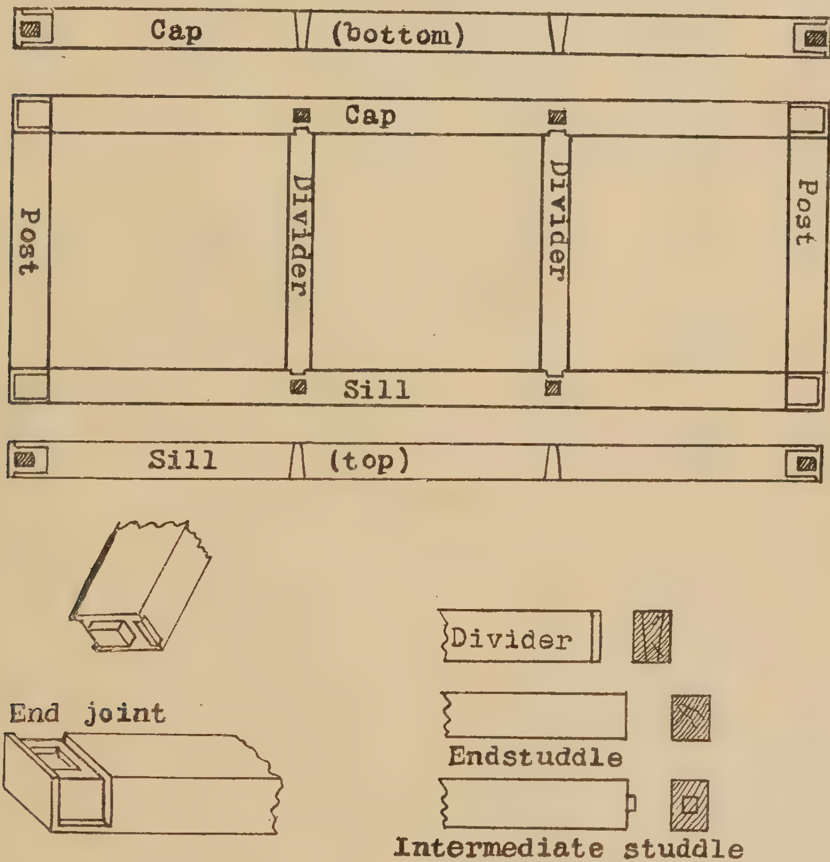


FIG. 93.—Frame-set for three-compartment inclined shaft.

ments being used as skip-roads, and the third as ladder-way, etc. The standard sets for such shafts consist of cap, sill, posts at the ends and at each division, studdles or distance-pieces opposite each post at back and foot, with the necessary lagging at the ends and over the back. On the Australian mining fields this type of shaft may be said to have been invariably adopted, and has been found to meet all requirements of even the largest mines. The Sons of Gwalia shaft at Leonora in Western Australia is 17 feet 2 inches by 5 feet 6 inches inside the timbers, the two haulage-ways being 5 feet 4 inches wide and the ladder-way 5 feet 6 inches, and the average monthly haulage during the busy times of the mine was about 13,000 tons. The Great Fingall shaft,

in the same State, was only 15 feet by 5 feet 6 inches, with two haulage-ways 4 feet wide, and a ladder-way 6 feet, and the monthly output was 21,000 tons for a long period. It will thus be seen that a shaft of moderate size can provide for a large haulage duty, and very good reasons should be forthcoming to justify the construction of larger ones than those mentioned. New Zealand has one inclined shaft 27 feet by 8 feet in the clear, but, despite the fact that very heavy water had to be dealt with, this shaft seems to have been of unnecessarily large dimensions.

Preparing Frame-Sets for Inclined Shafts..—In the actual preparation of the sets the methods followed vary almost as widely as in framing sets for vertical shafts. Figs. 93 to 95 show three different methods in common use. The first of these was adopted at the Sons of Gwalia, and other shafts in Western Australia. At the Sons of Gwalia, Oregon pine was used. The caps, sills, and posts were 9 inches by 9 inches, and the dividers 9 inches by 6 inches, but in part of the shaft the latter were only 8 inches by 6 inches. The end studdles were 8 inches by 8 inches, and the intermediate ones 9 inches by 6 inches. The lagging was 8 inches by 2 inches. It will be seen that the end posts, besides being checked to a depth of ½ inch in caps and sills, were also provided with 4-inch by 4-inch by 1-inch tenons which fitted into mortices in cap and sill. The intermediate distance-pieces were also tenoned to fit in mortices in cap and sill, but the end-pieces were merely secured in shallow daps of their own full section. Five hanging bolts of ⅞-inch iron were used in each set, two of them in the sill, one in the centre of the cap, and one in each end post near its top. The preparation of sets of this description requires a good deal of time and care, and it is questionable if some of the refinements in the framing serve any very useful purpose.

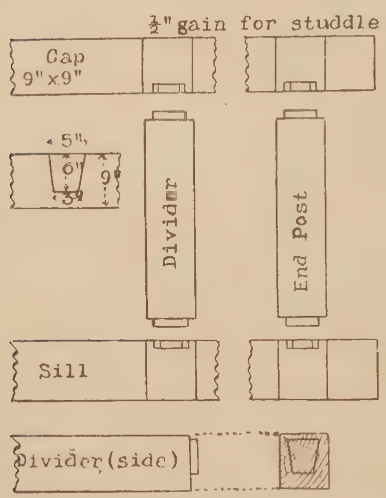


FIG. 94.—Frame-set for three-compartment inclined shaft.

The inclined shaft-set shown in fig. 94 is of much simpler character. The end posts and dividers are all of the same section, 9 inches by 6 inches, and are all cut in the same way, being provided with tenons 1 inch deep, which enter mortices in the sill and cap which are of 9-inch by 9-inch timber. The tenons and their mortices are only two-thirds as deep as the full width of the cap or sill. The distance-pieces are also all of the same size timber, and are let in on their full section to the depth of ½ inch into the caps and sills. The sills extend 6 inches on either end beyond the outer side of the endposts. Fig. 95 shows a set which is framed in practically the same way, the only difference of any importance being that the distance-pieces rest in a shallow check provided in the tops and bottoms of the posts and dividers.

In very large, inclined shafts the caps and sills are sometimes in two pieces, which are spliced over one of the dividers—preferably that between the ladder-way and the haulage compartments—as shown in fig. 96, or else are merely butted one against the other as in fig. 102.

Placing Sets in Position in Inclined Shafts.—This is an operation not

nearly so easily or conveniently performed as in a vertical shaft, principally by reason of the fact that the haulage rope cannot be made so much use of in lifting the timber. The cap is the most difficult member to get in place, as it has often to be lifted bodily by the workmen, and as it is ordinarily very

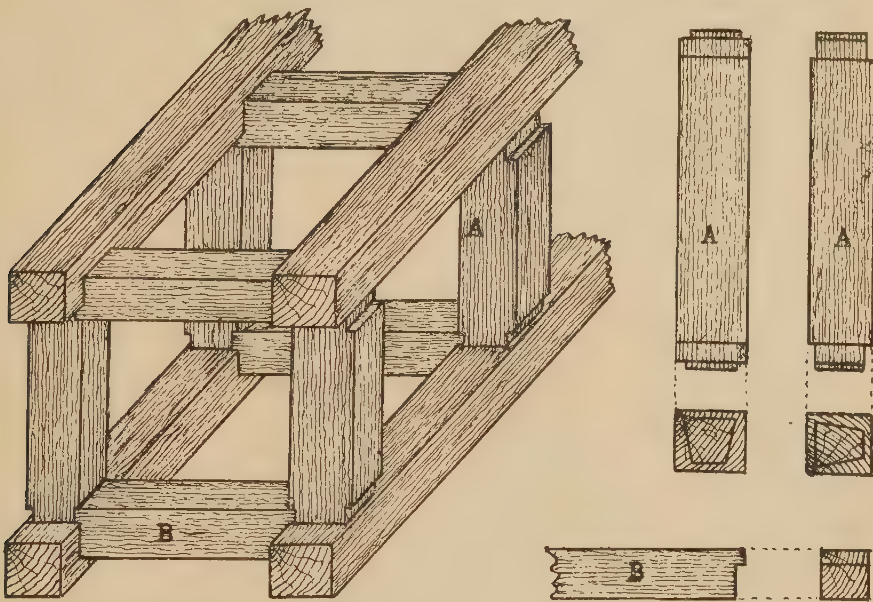


FIG. 95.—Frame-set for three-compartment inclined shaft.

heavy, the task calls for considerable exertion and care. In starting to put in a set, the sill is first sent down. The rope can be used to some extent in handling it until the two hanging bolts that are usually placed in it are got into position. The sill is then carefully levelled and aligned, wedges being

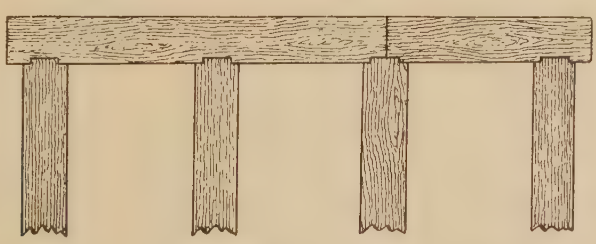


FIG. 96.—Method of making joint in two-piece cap in long inclined shaft.

driven at either end, if necessary, to prevent any possibility of it shifting. The two end posts are next stood in their daps, and the hanging bolts placed in them and screwed up until the posts are approximately in correct position. The cap is now lifted up and placed on top of the posts, the usual practice being to lift one end at a time, when the central hanging bolt is set in it, and partially screwed up. Before lifting the cap, precaution must be taken to see that the ground is out to give clear room for it. The dividers and studdles are now set in their respective places, after which the whole of the hanging

bolts are gone over and fully tightened up, wedges being driven in if required over the back and at the sides, every care at the same time being exercised to see that proper alignment of all members of the set is preserved. Finally the lagging is put in, and any spaces between it and the back or sides of the shaft are filled with suitable packing. To enable the workmen to get the heavy cap into position with less labour, it is sometimes possible to set two strong poles stull-fashion across the shaft, up which the cap can be slid, or to build up stagings in the shaft bottom in such a way as to greatly reduce the lift, but as a general rule the piece of timber is simply lifted up as previously described.

When two-piece sills and caps are used additional hanging bolts are re-

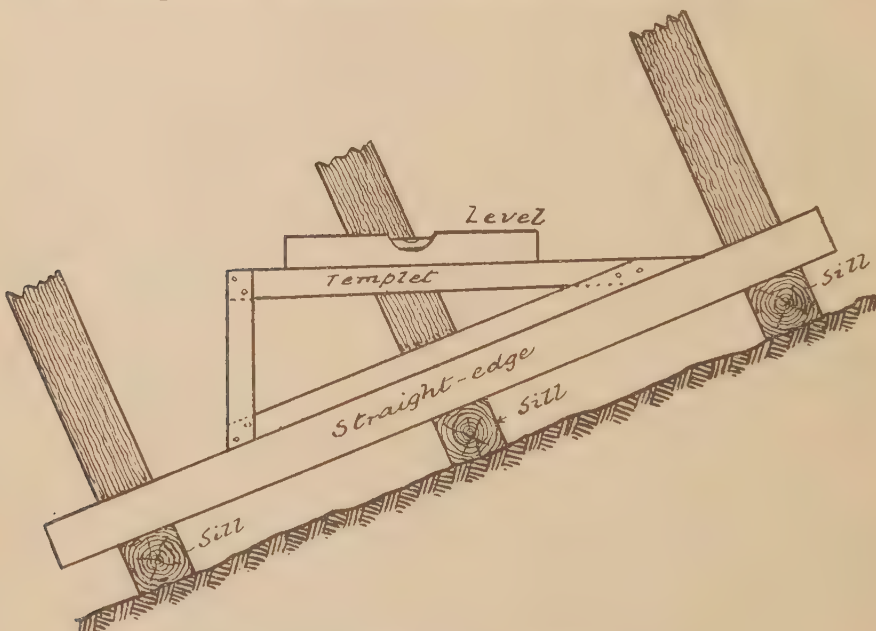


Fig. 97.—Aligning sets in inclined shaft.

quired, two being usually placed in each separate part, and further bolts may be needed in the dividers to support them in position while the set is being stood.

Alignment of Sets in Inclined Shafts.—As before mentioned, the sill is first aligned carefully, every precaution being taken to ensure that it is not merely in the same plane as the sills above it, but that its longitudinal centre is in true line with that of the shaft. The alignment of the sill is most correctly done with the transit, but is more commonly carried out by means of a straightedge, template, and level, as shown in fig. 97, or some form of combined straightedge and plumb-line as shown in fig. 98. The former may be said to be the Australian practice and the latter the American. If either of these devices are employed, the straightedge should be sufficiently long to touch the sills of at least three sets. The combined straightedge and plumb-line, instead of having a loose template, has one permanently forming part of it. From the top of the vertical side of the template a line is hung, on the lower end of which is a bob which swings in a hole cut in the lower end of the side. On

the face of the vertical side a line is marked with which the plumb-line should correspond when the sill is in horizontal alignment. To prevent the plumb-line swinging too freely, a small staple may be driven in about half-way between the bob and the top of the template. The perpendicular alignment is made by use of the straightedge alone. If, when the posts of the new set are stood, it is found that the straightedge when placed against the end of the shaft does not touch the new post and also the posts of the two previous sets, the post (or the sill if necessary) is moved one way or the other until the right position is reached.

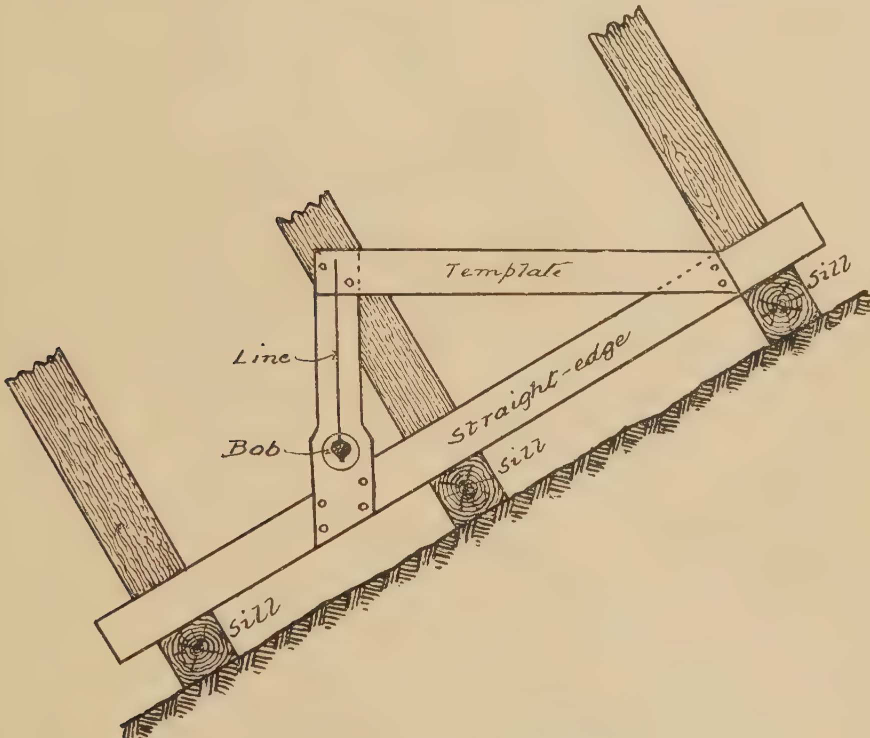


Fig. 98.—Aligning sets in inclined shaft.

If the alignment is done with a transit, the practice is to set the instrument up over a known point, about 2 feet from the shoulder of the cap or sill, and in the ladder-way by preference. Before the new sill is placed, a mark is made on it at the same distance from the shoulder as that at which the instrument is set. This mark may be made by driving a tack in the timber, making a slight sawcut, or even drawing a chalk line on it. A back-sight is taken for azimuth, then the sill is wedged one way or the other as required until the vertical wire cuts the mark, when the timber is in true perpendicular alignment. To obtain the proper inclination of the sill, the instrument is set at the dip of the shaft, its height is measured, and the distance from the line of sight to the sill calculated. The target of the levelling-rod is set at this distance, with its base resting on the sill, the rod being held perpendicular to the line of sight. The sill is then wedged up or lowered until the target is in line with the

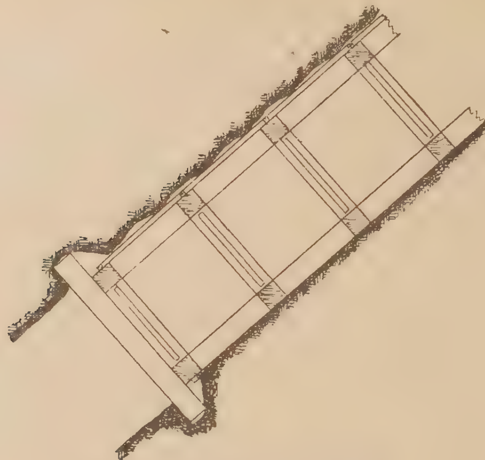


FIG. 99.—Bearers in inclined shaft.

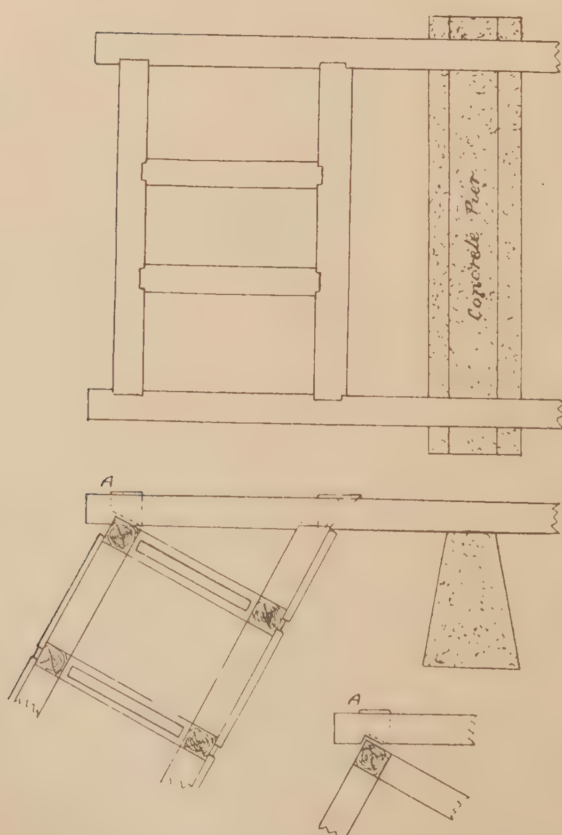


FIG. 100.—Collar-set for inclined shaft.

horizontal axis of the instrument. When the cap is in place, its alignment can be tested in the same manner. The corners of the set are then tested with a set-square, and the lay of the sill longitudinally with a spirit-level, when any necessary corrections are made, and the set again tested with the transit.

Instead of testing for alignment with the instrument, a simpler method is to make a mark on the sill in one of the ways mentioned, and stretch a string from it to a similar mark on a sill several sets higher up the shaft. The new sill is then moved one way or the other, as required, until the string corresponds with the marks in the intervening sets. The cap may be tested in a similar manner. A mark is made on it at the same distance from the end as the mark

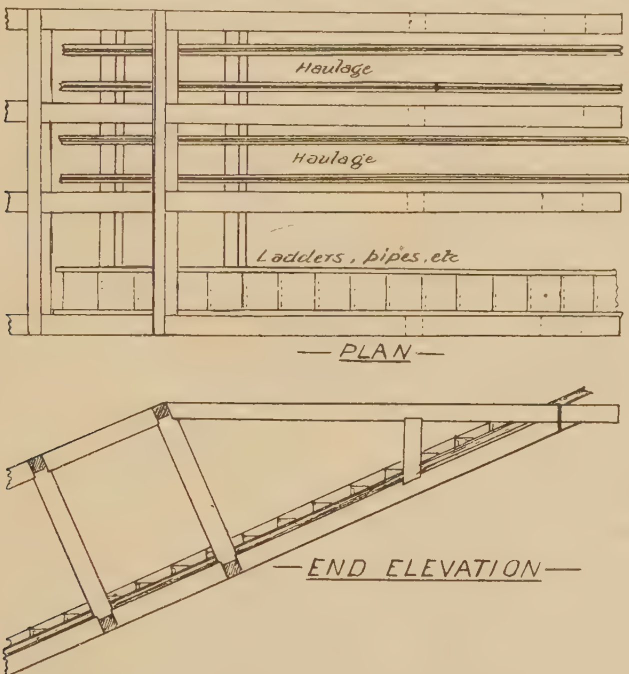


FIG. 101.—Collar-set for flat inclined shaft.

on the sill, and when the cap is in alignment a plumb-line dropped from the mark on it should hang directly over that on the sill. Once the set is stood any adjustments for correct alignment are made by driving wedges at the ends of the cap.

Bearers in Inclined Shafts.—The necessity for bearers in inclined shafts is not less urgent than in vertical shafts. The practice of putting them in is not always followed, but it is advisable it should be, suitable intervals being about 50 feet to 75 feet. As a rule the bearers are, as in the case of the vertical shaft, merely a pair of strong beams placed across the shaft under the sets, with their ends hitched into the walls, as in fig. 99. The method of putting the bearers in place is the same as has already been described as followed in the case of vertical frame-set shafts.

Collar- or Brace-Set for Inclined Shafts.—It need scarcely be said that the collar of an inclined shaft must be secured as strongly as that of a vertical one, and the methods adopted are in many respects similar. Long timbers are

placed to span well over the shaft opening, and if the surface on which they are to be placed is loose, masonry or concrete piers are built under them. Figs. 100 and 101 will serve to give a general idea of the ordinary way of forming the brace.

TIMBERING INCLINED SHAFTS IN HEAVY GROUND.

When the ground in which an inclined shaft is being sunk proves exceptionally heavy, it may be necessary to adopt some other method of timbering it than those described. If the pressure from the hanging wall of the shaft is not excessive, any difficulty there might otherwise be may be got over by shortening the spacing between the ordinary sets, say to 3-foot or 4-foot centres instead of the usual 5 feet to 6 feet. In some mining localities, however, so great is the pressure that no ordinary frame-setting method of timbering will withstand it, and other means of coping with the trouble have to be resorted to. In the inclined shafts in the conglomerate of the Calumet and Hecla Company, Michigan, U.S.A., the hanging wall is at times very heavy, and, to support it effectively, the novel combination of posts and square-set timbers shown in fig. 102 was employed. The method has been described by Rice (6) as follows: "When the shaft is first sunk, only the posts, or the 'end timbers' as they are called locally, are put in, and the shaft is made 22 feet by 9 feet, but after a time the weight begins to come on the roof and the shaft pillars begin to flake away under the pressure, increasing the width to about 25 feet by the time that the shaft-sets are put in. The posts are put in with foot and head-blocks, built up of 6-inch pieces criss-crossed to make a head-block 18 inches to 24 inches thick. Then when the weight comes on the posts, the crushing of these thick head-blocks gives the ground a chance to adjust itself to the new conditions before the posts are injured. Indeed, these built-up head-blocks serve quite well to take up what is called the initial creep in ground—the settling of the ground until it has adjusted itself, so that it takes most of the weight itself by forming an arch as it were—possibly better than a solid block would. The posts when first put in are about $6\frac{1}{2}$ feet long, from $2\frac{1}{2}$ feet to 3 feet in diameter, and the best of them are Georgia pine, a resinous variety which resists attack by fungus spores quite well. Posts of this pine last about two years before they need to be reheaded, and will stand three reheadings, each of which lengthens the post's life two years, so that the Georgia pine posts have a life of seven or eight years in these shafts. Some hemlock posts are used, which last about two years before they have to be replaced. No reheading of the hemlock posts is possible, as they rot too fast for it to pay. A few hardwood posts have been tried, but last scarcely a year, rotting into a mush-like pulp, in an amazing manner.

"The post is reheaded as soon as the head-block has been compressed to the limit, and before compression of the post itself has begun. Owing to the pieces in the head-block being laid so that they take the weight across their fibres instead of along them, the compression is confined entirely to the block until the last, when the wood fibre has become so compacted that it is as firm as the fibre of the posts. This reheading consists of sawing and chiselling out a cut across the top of the post so as to allow the post to be knocked out. About 6 inches is lost in this way at each reheading. Then a new set of foot- and head-blocks is put in, and the post is good for another two years, being practically as strong as when first put in. When the second set of head-blocks has been compressed to the limit, the post is again reheaded, but before the post has had to be reheaded the roof has begun to scale off, partly under the weight

and partly because of oxidation of lime minerals in the hanging wall. Lagging has therefore to be put in over the skip compartments, and this lagging is carried on regular sets such as are commonly used in incline shafts. Owing

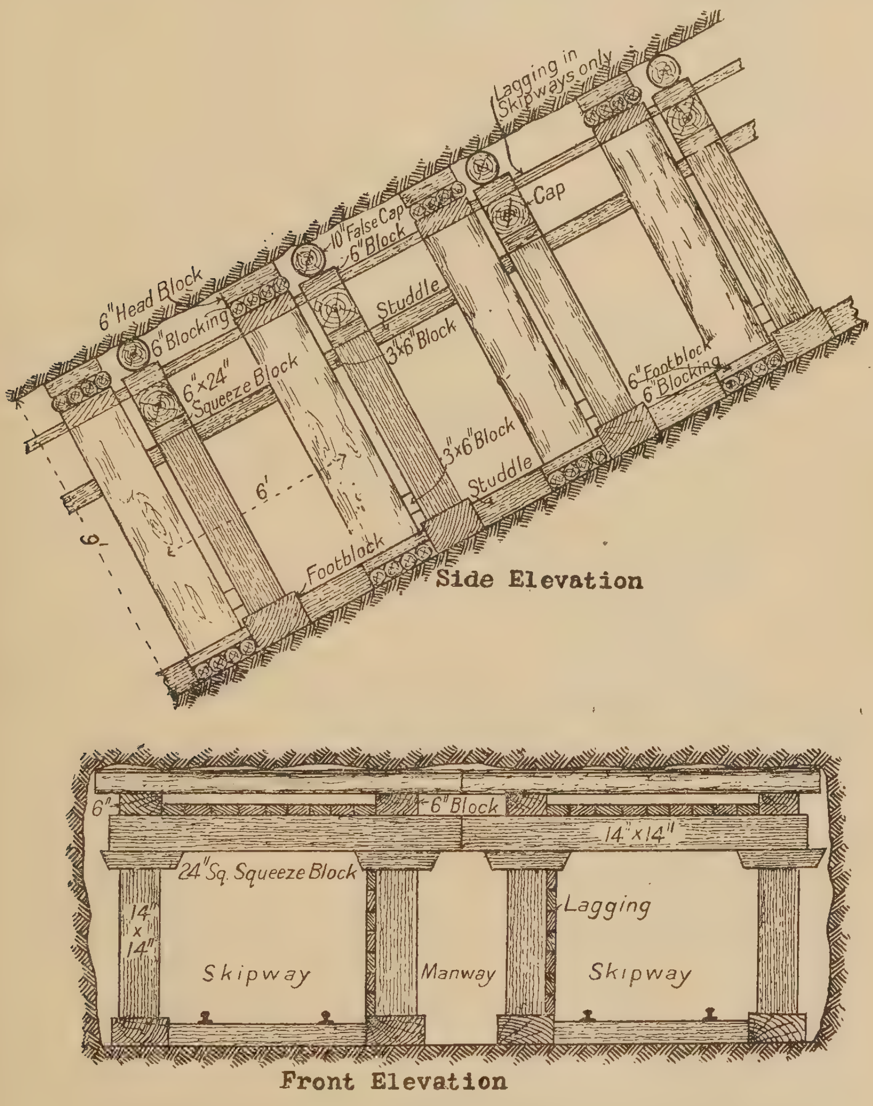


FIG. 102.—Timbering incline in heavy ground with combination of posts and sets.

to the swelling of the foot-wall, which gives especial trouble through raising and warping the tracks so that the skips will not stay on them, no sill is used under the shaft set; instead, foot-blocks of liberal proportions are put in.

"The lagging rests on 14-inch by 14-inch caps of pine. In a shaft having two hoisting compartments, the cap is in two pieces that butt against one another over the manway, which is placed in the centre. Above the cap

proper is carried a false cap of round timber wherever there is room enough. This rests on blocks placed on the cap-pieces directly over the posts. Under the cap and between the posts and the cap are squeezing pieces of 6-inch by 14-inch timber, about 24 inches long, with their ends bevelled so that they will bend and have less tendency to cut into the caps. The squeezing pieces take

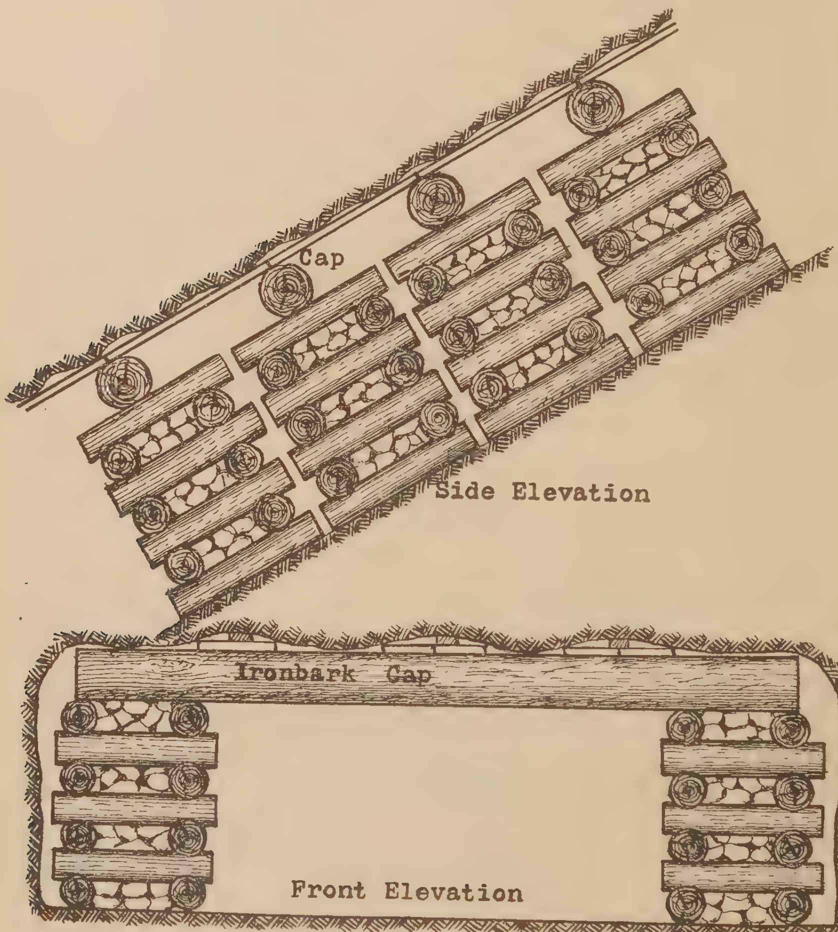


FIG. 103.—Timbering inclined shaft by use of cribs.

most of the crushing in these sets, as by them the pressure is distributed over a larger area on the cap than on the post. In other words, there is a concentrated pressure on the underside of the squeezing pieces, and a distributed pressure on the top side. Consequently the post cuts up into the underside of the squeezing piece, but the squeezing piece does not in turn cut the cap. As the weight comes end-on on the fibres of the post, it sustains little injury when it cuts into the squeezing piece.

"Studdles are put in to brace the timbers, always at the bottom and generally also at the top of the posts. In order to provide room for the circulation of air between the stull or end-timber posts and the square timber posts, as the

shaft sets are called, a 3-inch block is put in between. This prevents decay starting on the posts where the two would otherwise be in contact, as it is where there is dead air that the fungus spores which cause the decay first find lodgement and get a foothold.

"In easing the timbers, the men work on top of the lagging that is carried on the square timbers, and throw the rock that comes from the easing of the roof off principally at the far sides of the shaft, as it can be scraped down to the level and loaded on the sides more easily than if it were allowed to fall in the manway. Some of it cannot be prevented from falling in the manway, and is worked down to a level that way. By this arrangement the timbermen are able to work over the skipways without interfering with the hoisting in the least; indeed, it is in order to prevent that, as much as for any other reason, that the square timbers are put in.

"The combination of posts to take the bulk of the top-weight with sets to carry the lagging is a most admirable scheme for timbering inclines in heavy ground, for it throws the most of the wear and tear on the round posts, which are the cheapest elements in the combination to replace. Moreover, by using the squeezing pieces, owing to their acting much as head-boards between the caps and the posts, the caps are saved from injury and the life of the square timber sets is increased."

In the Day Dawn Mine at Charters Towers, Queensland, Le Neve Foster (3) mentions that where very heavy ground was met with the ordinary frame-sets were found quite inadequate. In this case, the severity of the pressure was due to the fact that the shaft had been sunk in the lode, and the ore on either side of it taken out and replaced by filling. The shaft had been timbered with ordinary lagged frame-sets which would probably have been found to support the hanging wall satisfactorily under ordinary conditions, but the weakening of the wall by the removal of the ore threw undue strain on the timbers. This practice of removing ore from the vicinity of a shaft is to be condemned, for it inevitably leads to trouble. The best modern practice is always to leave a solid pillar of considerable dimensions around or at either end of the shaft. The difficulty at the Day Dawn Mine was got over by removing the filling from the ends of the shaft, and building cribs of strong timber, as in fig. 103. Long, heavy caps of ironbark timber were then placed across the shaft on top of the cribs and lagged over. After the adoption of this method the shaft gave no further serious trouble. The subsidence of the hanging wall continued, but the cribs yielded to the movement without being badly crushed. A cap would occasionally break, but was readily replaced.

CHAPTER III.

COMBINED SHAFTS.

The practice of changing direction in shaft sinking is common. In the majority of cases the change is from the vertical to the underlay (inclined), rare instances only occurring when it is in the reverse order. In the case of a lode dipping at a comparatively low angle, the amount of crosscutting to be done to reach it at each succeeding level, once the lode has been passed through with a vertical shaft, increases rapidly, entailing an amount of unremunerative expenditure that may easily mean all the difference between profit and loss in the carrying out of subsequent mining operations. In other cases, such as those of the deep-level shafts of the Witwatersrand field in South Africa, it may not be possible or convenient to sink an inclined shaft from surface. The banket formation on this field dips away so rapidly that mining companies working properties on the second or further rows from the outcrop could only sink such shafts through adjoining claims. Again, it may happen that a lode that dips at a fairly high angle at the surface may straighten up with depth, with the result that an inclined shaft sunk on it would, if continued down, pass off to a distance into the hanging-wall country, and be practically useless for development purposes. In all such circumstances resort to the combined type of shaft is practically compulsory.

Whatever may be the nature of the necessary turn, whether from vertical to inclined or *vice versa*, the methods of setting the timbers need not vary greatly from those already described. As a general rule, in shafts of small dimensions in which very rapid winding is not essential, or in shafts that are being changed from an inclined to a vertical direction, the practice is usually to set the timbers at regular intervals, as in the timbering of any ordinary straight-line shaft, but in such a position that each set stands as nearly as possible at a right angle to the walls of the curve. An illustration of this method of timbering is given in fig. 104, which shows the turn from inclined to vertical at the Long Tunnel Mine, Victoria, as described by Finlayson (41). In this case, the method of framing the sets is exactly the same as that usually followed in timbering a vertical shaft, except that the posts and studdles are shortened on the inner side of the curve and lengthened on the outer side, so that the sets conform evenly to the radius of the curve determined on. Before a change of direction of any kind is started there should be definite data available as to the dip of the lode below the curve so that in setting out the latter the true radius required to bring the lower part of the shaft into its proper line may be determined without error.

Once this radius is known, the preparation of the sets offers no greater difficulty than that of any other class of shaft timbering. The ordinary procedure is first to draft out a full set to scale on paper, and from the data thus afforded to prepare templates from which the posts and studdles, which are

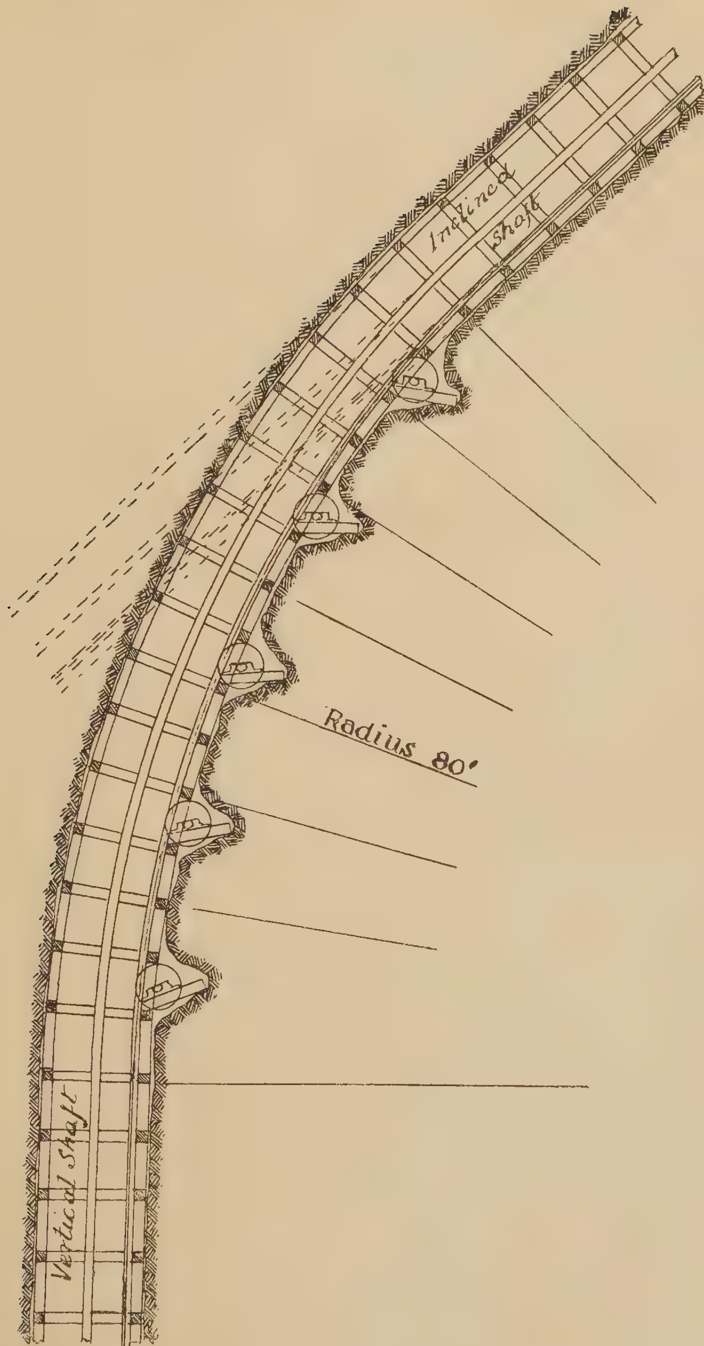


Fig. 104.—Changing direction of shaft from inclined to vertical.

the only members of the set differing from the usual, may be marked off. Apart from the inner and outer posts and studdles having to be cut to different lengths, the tops and bottoms of each require to be bevelled slightly to conform with the curve and make good joints with the plates, and it is a good practice first to prepare two full sets, with the necessary posts, etc., and set them up on the surface in order to make sure all the members are cut just right before going on with the preparation of the rest of the timber. As the sets are put in, they are secured in the usual way with hanging bolts.

In changing from vertical to inclined the same method of timbering may be followed, and may be the only one possible.

When the curve is being made in a shaft of small dimensions that has been timbered with box-sets, similar sets may be used in forming it, the plates on the outer side being blocked up to conform with the radius of the curve, but, owing to the heavy strains to which the timber is subjected in such situations, it is preferable at all times to use frame-sets, the more substantial nature of which enables them to stand up better to the task imposed.

When a change from vertical to inclined is being made in fairly strong ground, other methods than those described are usually followed. One of these is shown in fig. 105, and represents the method adopted in the shaft of the Great Fingall Mine in Western Australia. The procedure observed has been described by Cleland (1) as follows: "In the vertical portion of the shaft at a point where the deviation commences, a strong cap-piece of timber, similar in size to the cap-piece of a plat-set, is laid lengthwise in the shaft and tightly wedged in deep hitches cut in the solid rock on that side of the shaft where the vertical junctions with the back of the underlay. This serves to support the timbering of the vertical portion of the shaft, and the ends of the posts and studdles are morticed into it. From below the cap-piece the side of the shaft is cut away on a curve having a radius of 50 feet, and is produced to a point at which the regular underlay shaft commences. Below the actual point of deviation, the vertical portion of the shaft continues sufficiently far to form a sink for the collection of, say, water draining down the shaft. Bearers are fixed in this portion of the shaft below the curve, wall-plates are placed on the bearers, and posts and studdles are set up vertically on the wall-plates and tenoned into the cap-pieces above; the positions of these timbers coincide with those of the corners and studdles of the vertical shaft. The posts, however, are of 12-inch by 12-inch timber and 28 feet in height; the studdles are of the same thickness as those in the vertical shaft, but of greater width. The longer dimension stands at right angles to the length of the shaft as in a plat-set. These upright timbers are connected with the dividers by mortice and tenon joints, and are braced to the timbers on the opposite side of the shaft with strong bolts passing through below the dividers. The back of the underlay shaft round the curve is supported by posts and cap-pieces with stout lagging between caps and backs. Posts and caps are of 8-inch by 8-inch timber, carefully jointed. The posts are fixed on the radial line of the curve, and their bottom or foot ends junction with the 12-inch by 12-inch timber in the vertical shaft, the timbers being morticed about 2 inches deep to receive the posts.

"The skip-track round the turn is carried on 8-inch by 8-inch bearers fixed lengthwise in the vertical shaft and resting on the dividers, to which they are firmly bolted. They are, of course, so placed that they conform to the curve of 50 feet radius. Skip guides, or runners, at both ends of the hoisting compartments, traverse both the vertical and underlay portions of the shaft from top to bottom. The guides are of hardwood 5 inches by 4

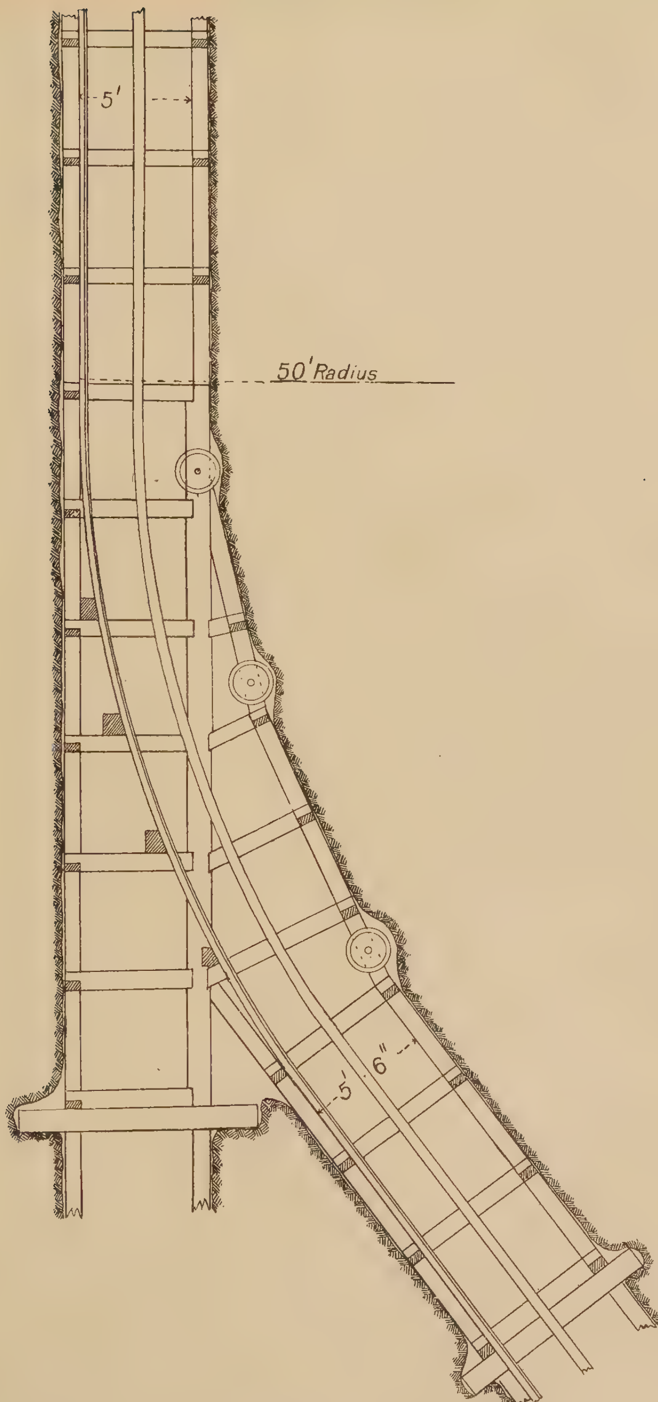


FIG. 105.—Changing shaft from vertical direction to inclined.

FIG. 106.—Another method of timbering employed when changing a shaft from vertical to inclined.

inches, and the average length 24 feet; they are placed so as to engage with shoes on the skip frame."

In this shaft the timber was all Oregon, the frame-sets of the vertical and underlay sections being of 8-inch by 8-inch material, with 8-inch by 6-inch dividers.

In the deep-level shafts of the Witwatersrand an even more elaborate method of timbering is followed when making these curves. Fig. 106, which is after an illustration by Leggett (11), will serve to give a fairly clear idea of it. It will be seen that the bearers under the vertical part of the shaft are 16 inches by 8 inches in cross-section for the outside and 16 inches by 6 inches for the intermediate timbers, bearers being placed between each compartment. The bearers immediately above the sump are of similar dimensions. The end-plates are 12 inches by 8 inches, and the posts and diagonal struts under them 8 inches by 8 inches, but the dividers are 12 inches by 6 inches, with posts and diagonals of 8 inches by 6 inches, the longer dimension in all cases being placed at right angles to the length of the shaft. The wall-plates in the vertical part of the shaft are 12 inches by 8 inches, and dividers 8 inches by 8 inches. End-plates and dividers through the curve for their full length are in one piece. The whole construction is well-strapped together, both vertically and horizontally, with hanging and tie bolts of 1 inch diameter iron.

It is not necessary that any further details than those furnished be supplied, for the reason that the length of timbers, or their spacing, must depend entirely on the radius of the curve that has to be made, and this differs more or less in every mine. Even the giving of the sizes of the timbers in this case serves no other purpose than that of affording a sort of general guide, as in all cases those employed in any mine will be determined by such factors as the class of timber available, the nature of the ground, and the sizes of timber used in the vertical part of the shaft. It need scarcely be said that the method can be varied to suit changes of conditions in various places.

It is evident that in timbering in this manner a considerable, and what may even be thought an unnecessary, amount of ground has to be opened up. In bad standing country it would not be easy to make or maintain such a large opening, and hence some simpler way of securing the curve would have to be adopted, but where it is possible to remove the ground on the foot-wall of the curve in the manner shown it is considered advisable to do it, as the construction is thereby admitted of a framing that makes it possible to put in a curve that will be absolutely rigid under all conditions of work. Leggett (11) remarks that if the timbering were not placed in this way a much lower degree of security would be possible.

CHAPTER IV.

OPENING OUT FOR PLATS OR STATIONS. TIMBERING PLATS.

All mining engineers nowadays recognise the necessity of providing abundant room on what are variously known as the plats, stations, or chambers of a mine. At one time it was quite common to see plats that were but little wider or higher than an ordinary drive or crosscut. Modern experience demands, however, in the interests of safety and economical working, that much more commodious entrances to levels shall be provided.

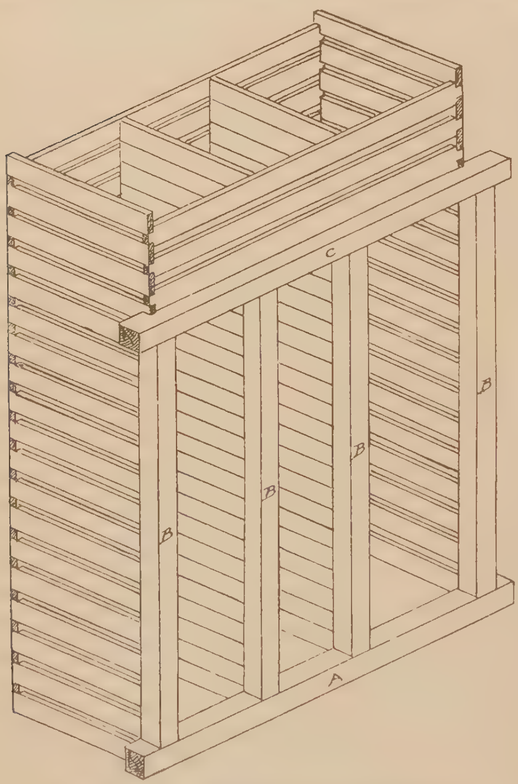


Fig. 107.—Opening-out set in boxed shaft.

In opening out, a good deal of consideration is given, therefore, to the height of the opening-out sets. In all cases these are of the full width of the shaft, but their height varies. As a rule it ranges, in a vertical shaft, from 10 feet to 12 feet. The object aimed at in determining the height is to ensure that sufficient headroom is left to allow of convenient removal from the cage of the longest rails, pipes, timbers, etc., likely to be required on the level, and for bringing in compressed air, water, or ventilating pipes from the ladder compartment at such a height above the flat-sheets as to be well out of the way of trucking operations. Another point that has to be kept in mind when the question of height is being decided is that the further sinking of the shaft will probably be carried out from the new level, consequently sufficient height must be allowed for the erection in the ladder compartment of a stage for landing the dirt broken during the sinking, and for handling the shaft timbers that will be required.

Opening Out from a Vertical Shaft.—Whether the new plat is to be opened out from a boxed- or a frame-set shaft, the procedure is much the same. When the ordinary shaft timber has reached a position approximating the head of the plat, care is taken to see that it is secured against any possibility of movement. In the case of a frame-set shaft the hanging bolts will render all the support necessary, but in a boxed shaft it is a wise precaution to strap a number of the lowest sets together by spiking vertical cleats to them. The sinking is then continued to what will be the bottom or floor of the plat, and

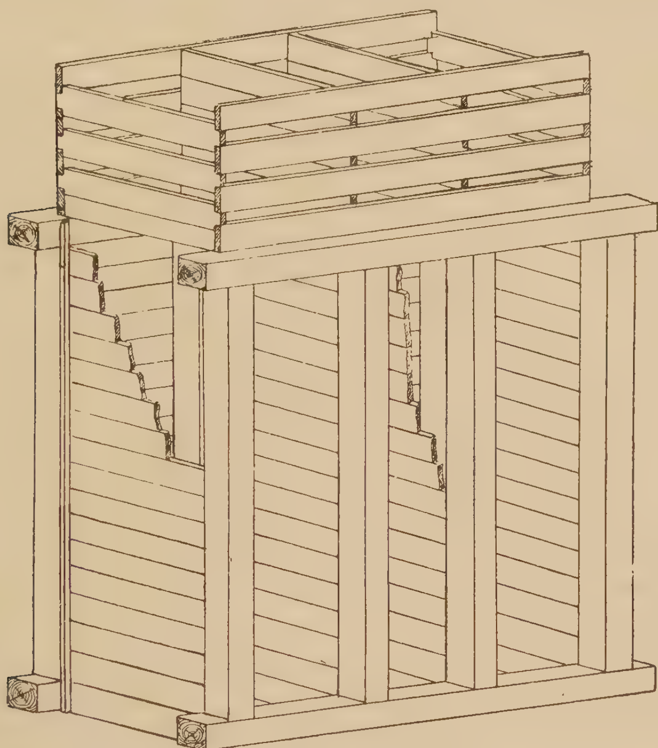


Fig. 108.—Opening-out sets on both sides of boxed shaft.

a round of holes is bored in the side of the shaft at which it is intended to open out. If plats are to be opened on either side, as is sometimes necessary, both walls are bored out. The shaft is now carried down some distance further to form a sump or well-hole. Stout bearers are next put in hitches immediately below the position the sill or sills of the opening-out set or sets will occupy. Across these strong slabbing is laid temporarily, after which the holes bored in the shaft sides are fired. If the ground to be excavated is of good standing nature, further rounds may then be bored out, and the entire plat may be cut before any more timbering is done. In case the ground should not be strong, once the broken rock from the first round of holes mentioned is cleaned away, a start is made to stand the opening-out set or sets by first removing the slabbing with which the bearers have been covered. If the shaft is being timbered with box-sets, and it is only intended to open out on one side, a single sill piece, such as shown in fig. 107, is sent down and placed in position.

On this the uprights BB are stood, and the cap C placed on them. The whole set is then firmly blocked and wedged to the timber above, and at each end of cap and sill, after which the ordinary box timbering is built up on the bearers, and packed and wedged in the usual way. To further secure the opening-out set, bolts are passed through the uprights and the wall-plates on the opposite side of the shaft. They are not shown in the figure, but are generally used.

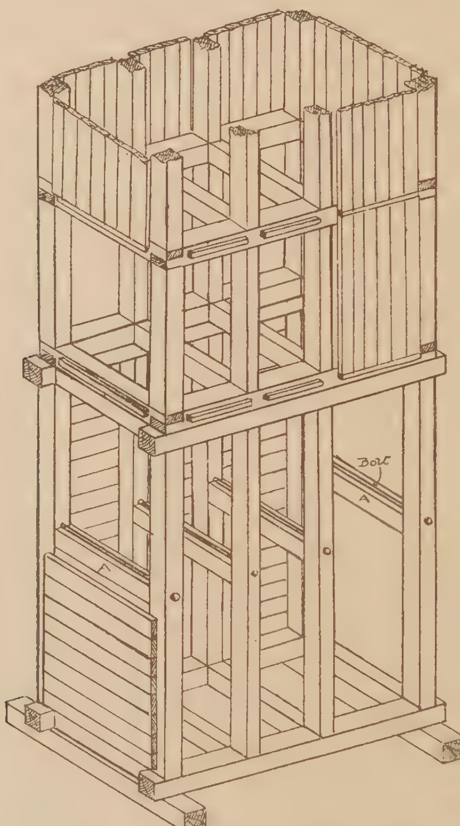


FIG. 109.—Opening-out sets in frame-set shaft.

Three bolts are used for each upright, one near the top, bottom, and centre respectively.

When it is intended to open out on both sides from a boxed shaft, a similar set is erected on either side of the shaft, as in fig. 108, and it may be said that in all cases it is good practice to do this. It is very necessary that all plat timbering is made very secure, and there can be no questioning the fact that the use of double sets in this way ensures stronger and more rigid construction of the whole framing.

To secure the end-plates and dividers or centres in place, cleats are nailed on either side of them to the inner faces of the uprights.

When opening out in a frame-set shaft, one opening-out set, as in fig. 107, may be used, the other three sides of the shaft being built up of ordinary frame-set timbers, but by far the most common practice is to use double sets,

as in fig. 109. Cross-pieces corresponding with the end-plates of an ordinary set are usually put in between caps and sills at their ends, and at each divider, and one or more spreaders AA at intervals between the uprights. The lagging

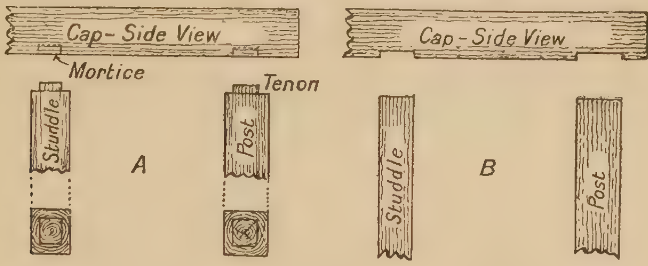


FIG. 110.—Cap and post joints for opening-out sets.

in this part of the shaft is in most cases placed horizontally instead of vertically, short lengths of timber being used to span from upright to upright.

In framing the opening-out sets, the joints between the uprights and the

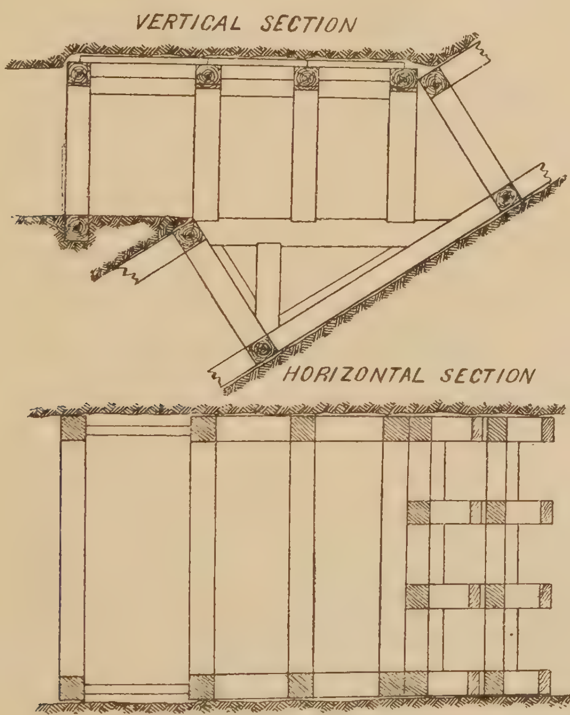


FIG. 111.—Opening out from an inclined shaft.

caps and sills, and between the uprights and the spreaders are generally made by tenon and mortice as indicated in fig. 110. Occasionally the uprights are merely housed into the caps or sills as shown at B in fig. 110, but this method of securing them is not to be commended.

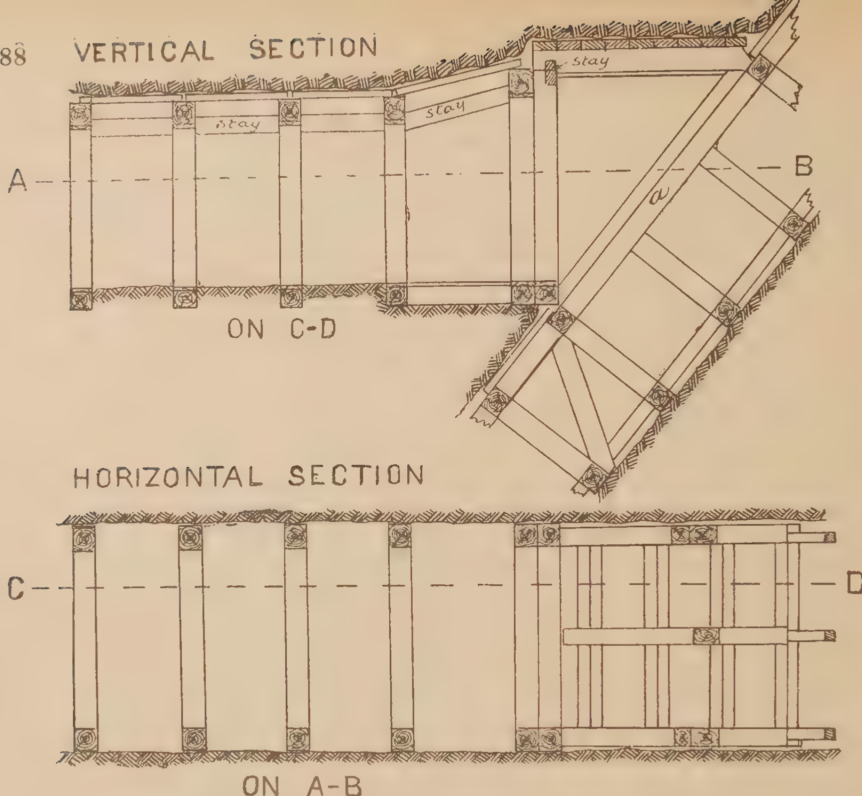


FIG. 112.—Opening out from an inclined shaft.

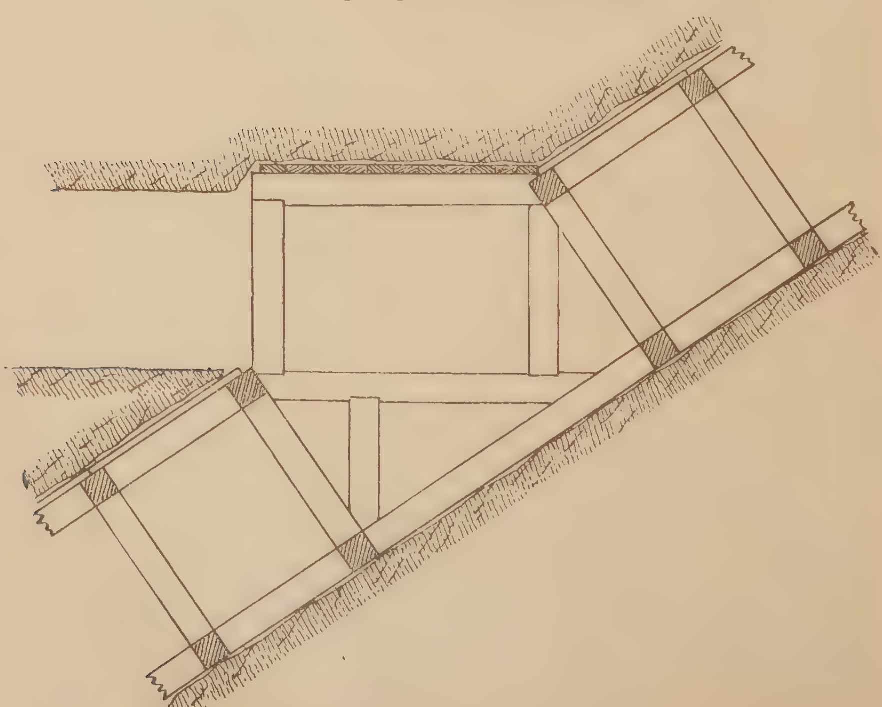


FIG. 113.—Opening out from an inclined shaft.

Opening Out from an Inclined Shaft.—The practice of sinking below the timber for some little distance, and boring out a round of holes in the shaft-side is followed, as in the case of a vertical shaft, but the securing of what corresponds with the opening-out set is carried out in a variety of ways, the exact method adopted being to a great extent dependent on the dip of the

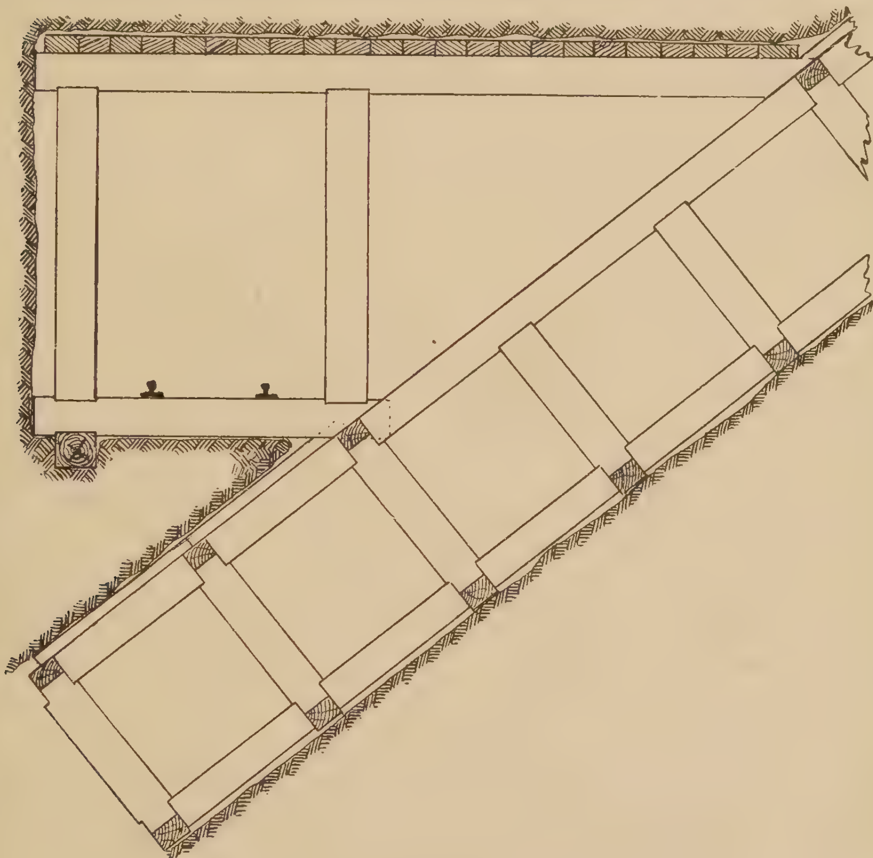


FIG. 114.—Opening out from an inclined shaft.

incline. Figs. 111 to 114 will serve to illustrate several of the more generally approved methods. In the horizontal sections of the first two of these the lagging over the back has, for the sake of clearness, been omitted, but sufficient detail has been given in all the figures to enable a clear idea to be gathered of the various framings.

TIMBERING OF PLATS.

It happens at times in mines that large plats can be opened without the necessity for timbering them, but in by far the greatest number of cases it is necessary, or at least advisable, to support the openings. Ground that appears solid when first opened out often loosens up on exposure, and as the plat is a busy part of a mine, the danger to be apprehended from slabs of rock dropping

away unexpectedly from the back is too serious to justify any risks being taken.

The size of the plat must be determined by circumstances, but the modern practice is to make them large enough to meet all possible demands. In width, they are usually of the full overall dimension of the shaft, but in many mines they are at least 1 foot wider on each side. This is to prevent the legs of the plat-sets interfering in any way with the approach to the cage openings. As to how far they are carried back, that depends on the size of the mine, and on its requirements, and may vary from 10 feet or 12 feet to 50 feet or more. In some instances, the plat is excavated for its full length to the height of the opening-out set, but it is seldom necessary to adopt this plan, and the more general practice is to slope the back gradually from front to rear as shown in figs. 115 and 116. The spacing of the plat-sets varies, according to the nature

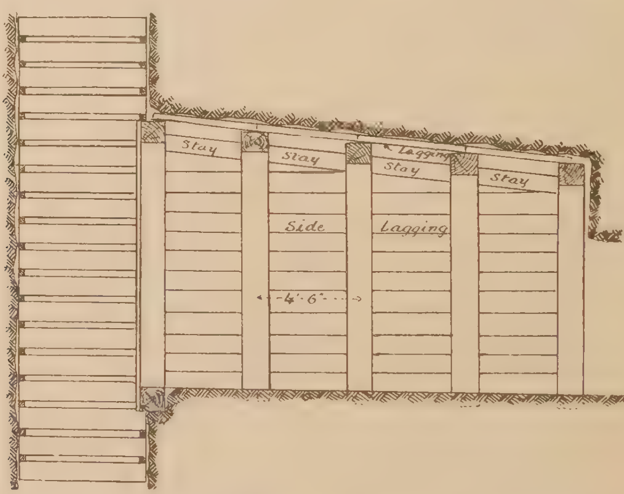


FIG. 115.—Method of timbering plat from vertical shaft.

of the ground in which the excavation is being made, and may range from 3-foot to 5-foot centres. In country from which no serious pressure is expected, and the main object in timbering is merely to prevent unexpected falls, a usual distance is about 4-foot 6-inch centres. Round or squared timber is used at choice, but it is preferable to employ the latter, as the removal of sap timber during the squaring tends to lengthen the life of the timber by offering less chance to the fungi that flourish in most mines to get in their destructive work.

Occasionally the first set is stood at the regular set-interval from the opening-out set, as shown in fig. 115, but the adoption of this method means that the lagging of this set rests on the opening-out set, and throws an undue amount of weight on it, which sooner or later may result in the breaking of the cap. The more generally approved practice is to stand the first plat set just outside the opening-out set, as in fig. 116. By doing this the shaft timber proper is relieved of all unnecessary pressure, and at the same time support is given to the back of the plat at its weakest point, the brow of the opening.

In practically all cases plats constructed in reasonably good ground are timbered much in the way described, but in past years other methods have been followed. Fig. 117 shows a style of plat-timbering that was favoured for years

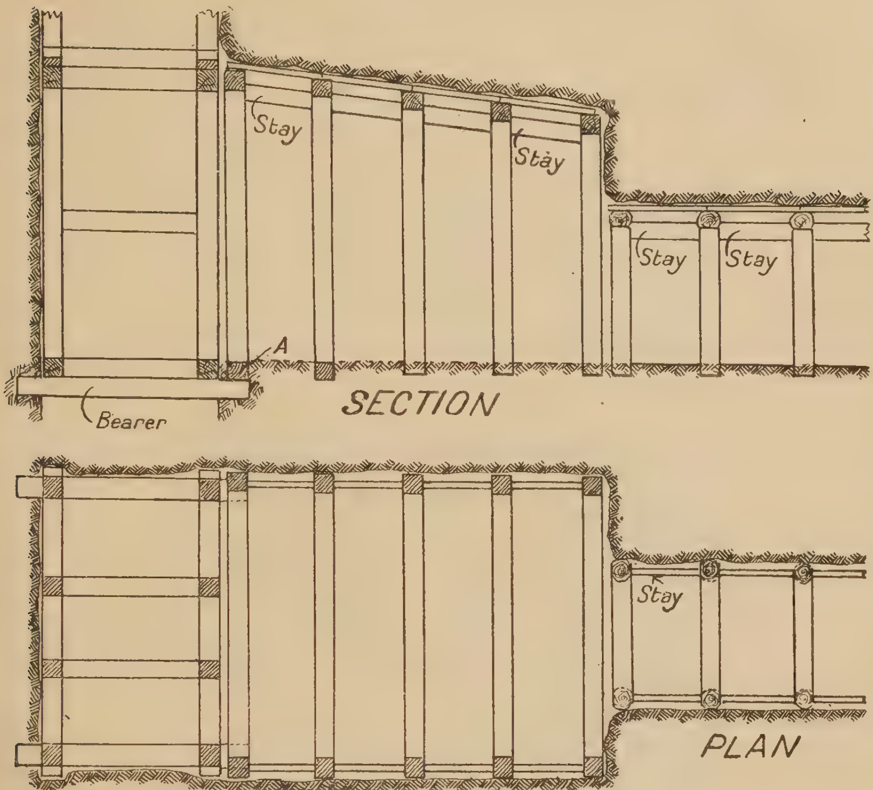


FIG. 116.—Timbering plat in vertical shaft.

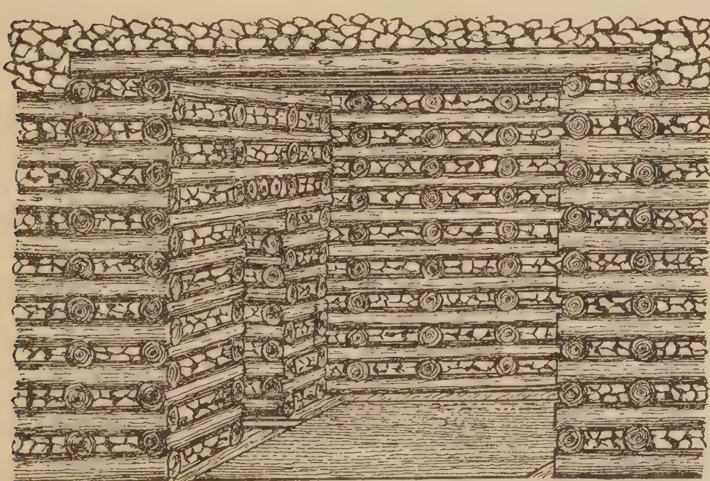


FIG. 117.—Crib method of timbering plat in lode.

on the once important Cobar copper-mining district, in New South Wales, especially when the plats were in the lode. The method was one of simply surrounding the opening with walls of cribbing, laced over with stout poles. This type of plat gave good service.

PLAT TIMBERING IN HEAVY GROUND.

Instances are somewhat rare where, owing to excessive pressure from the surrounding country, special methods of securing the plat, other than those already described, have to be adopted, but there are certain mining fields where, from this cause, great trouble is experienced in maintaining these underground openings, and most elaborate and costly methods of securing them have

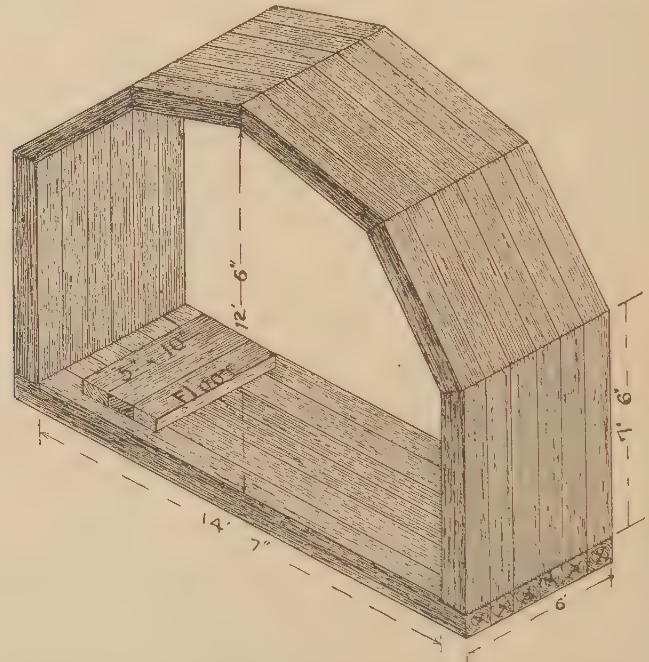


FIG. 118.—Timbering plat in heavy ground—later Butte method.

had to be resorted to. In the Butte copper region of Montana, U.S.A., where an excessively heavy roof and a swelling floor have to be dealt with, the various mining companies have been faced with extraordinary difficulties in keeping plats open. In order to cope with the position, the trussed and reinforced set shown in fig. 119 was largely used, and became for some years the standard station-set. The principal members of it were of 12-inch by 12-inch timber, with 5-inch lagging on top of double caps, and 5-inch flooring. In the Blue Rock Mine, Parsons (2) mentions that even this method of support did not prove satisfactory, the double caps breaking under the excessive weight from the roof, and the buckling of the floor causing expensive repairs. By way of experiment, a plat was timbered, as shown in fig. 118, and the results proved so good that the method was subsequently fairly widely adopted, the skin to skin arch evidently being able to resist pressure to a much greater degree than the

older method in general use. In some of the mines heavy arches of concrete, up to 5 feet in thickness, were tried, but were unable to stand up to the pressures

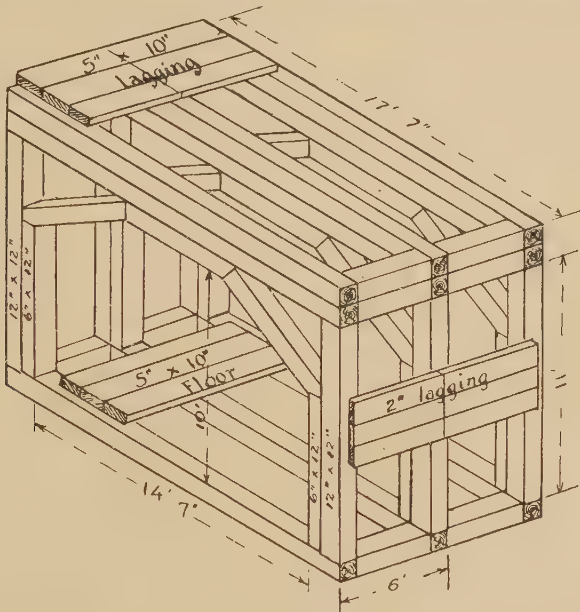


FIG. 119.—Timbering plat in heavy ground—old Butte method.

exerted against them, and the evidence seemed to be that wooden arches of the type shown gave better results. In very troublesome ground, therefore, this style of timbering, although it may seem unnecessarily elaborate and costly, may be well worth trying.

CHAPTER V.

PENTHOUSE CONSTRUCTION.

When sinking is resumed from a level it is now not merely the usual custom throughout the mining world, but in certain mining countries is made compulsory by law, to provide something in the nature of a penthouse ("pentice," U.S.A.) to protect the men engaged in sinking from injury from material falling

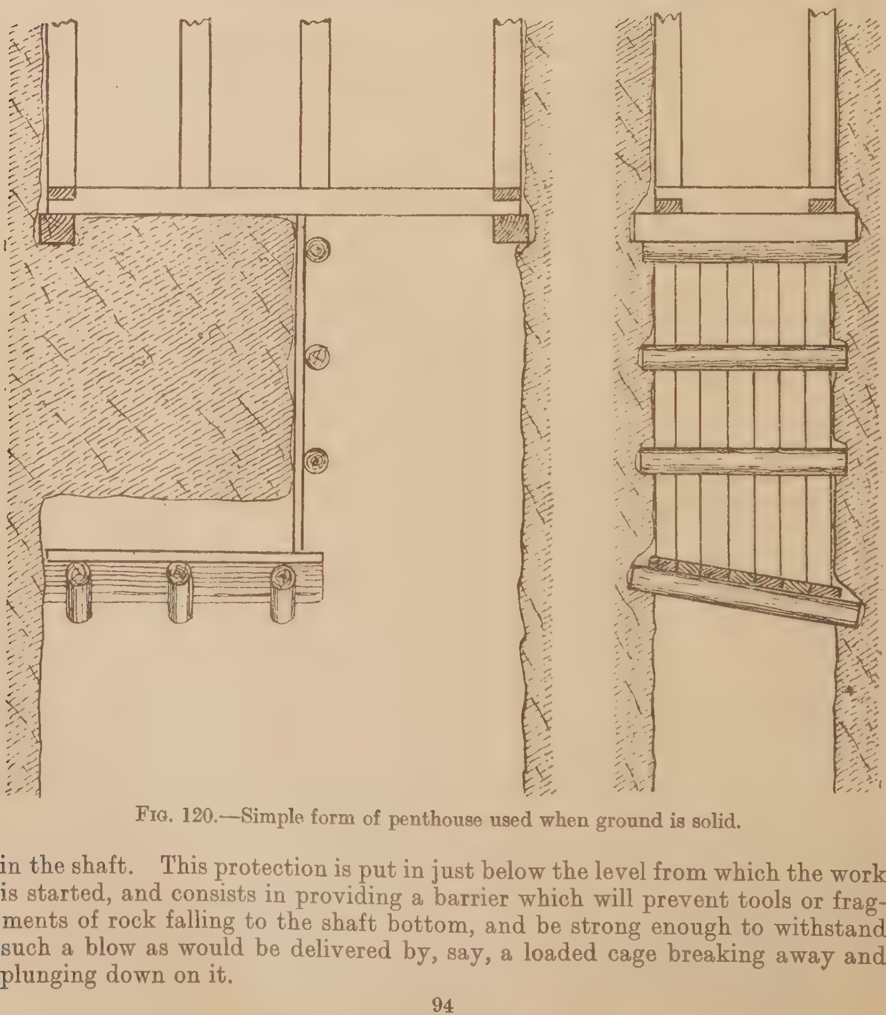


Fig. 120.—Simple form of penthouse used when ground is solid.

in the shaft. This protection is put in just below the level from which the work is started, and consists in providing a barrier which will prevent tools or fragments of rock falling to the shaft bottom, and be strong enough to withstand such a blow as would be delivered by, say, a loaded cage breaking away and plunging down on it.

However many compartments there may be in the shaft, the procedure is invariably to place this barrier in all except the end compartment, usually the ladder-way, through which the rock from the sinking will be hauled.

In some mines, where the country-rock is of strong-standing character, the practice is to use the rock itself for the purpose, as indicated in fig. 120. A small opening, the size of the ladder-way only, is sunk in the shaft bottom, and this is subsequently opened out to the full size of the shaft, leaving a strip of solid ground that may be anything up to 10 feet or 12 feet thick under the haulage compartments. When the rock is sufficiently compact to meet all

FIG. 121.—Penthouse in boxed shaft.

requirements, a penthouse of this kind will serve its purpose well. Even when the rock is not strong it is still possible to use it as a penthouse by supplementing it with timber as shown in fig. 120. By hitching a few logs into the walls in this way, and lacing around the barrier with planking, any small pieces of the rock that fall away are prevented from doing injury.

In most mines, penthouses are constructed of timber so placed as to form a box into which sawdust, shavings, ashes, clay, sand, or fine mullock are filled to a depth of some feet. A general rule in shaft-sinking is to continue each lift for a certain distance, say 20 to 30 feet, below the new plat, this lower part being used, pending a resumption of sinking, as a sump or well-hole to catch the drainage of the mine. The regular shaft timbering is carried down to the bottom of it, consequently when the time comes to put in a penthouse a ready means of fixing it is available.

If the shaft is timbered with box-sets, a common practice, when starting on the construction of the penthouse, is to either remove a set, or, by knocking out the chocks, drop one or two of the sets at a point 10 feet to 12 feet below the floor of the plat. In fig. 121 the chocks have been removed and two sets dropped. In the space thus provided, timbers of fair size, say 6 inches by

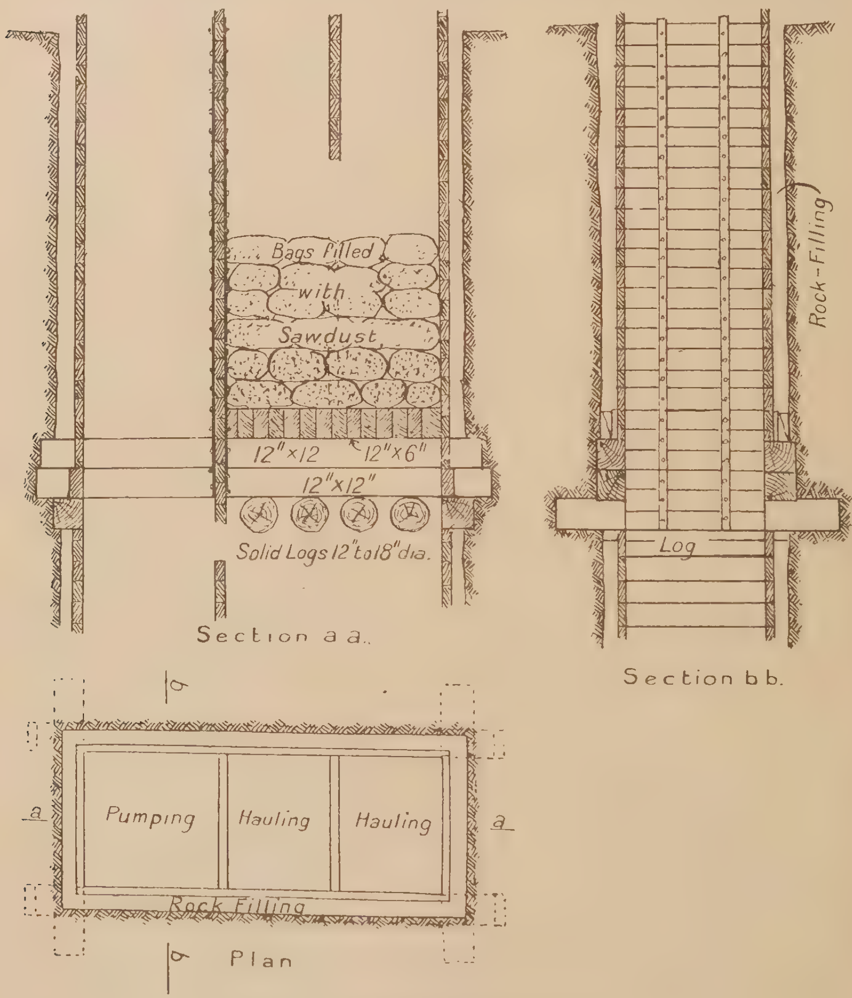


FIG. 122.—Penthouse in boxed shaft.

6 inches at least, are laid across the shaft in the haulage compartments, a few of the dividers between the latter being removed for the sake of convenience. Further 6-inch by 6-inch timbers are then laid lengthwise on top of the cross-pieces, and the box thus formed is filled to within a short distance of the sill-set of the plat with some one of the filling materials previously mentioned. To enable this material to be readily removed when the penthouse is no longer required, it is often placed in bags.

Fig. 122 shows another method of fixing a penthouse in a boxed shaft.

Instead of some of the sets being removed or dropped, stout bearers are hitched across the shaft at each end, and also under the haulage-ways, and on these, at either side of the shaft, are placed two 12-inch by 12-inch timbers, one on top of the other, let into hitches in the ends of the shaft. On these, in turn, further timbers, this time of 12-inch by 6-inch material, are laid closely across the shaft, and on the floor thus provided the filling is packed. The dividers on the ladder-way side are strapped together by means of narrow strips of flat iron which are bolted to each to give them additional strength.

Yet another method of arranging a penthouse in the same type of shaft is shown in fig. 123. This closely resembles the method last described, the chief

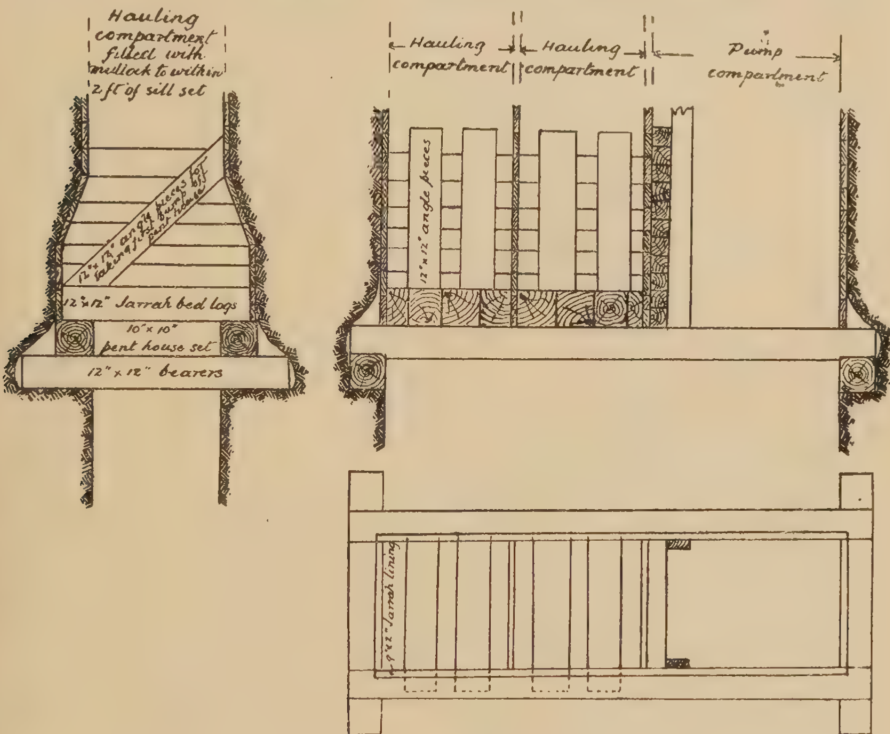


Fig. 123.—Penthouse in boxed shaft.

differences being that the cross-bearers under the penthouse are left out, and, in place of them, diagonals are set across the shaft above the penthouse floor. The use of iron straps on the dividers on the ladder-way side is also dispensed with, cross-pieces of 6-inch by 6-inch timber being built up skin to skin outside them, and held in position by means of strong cleats.

A fourth method for a boxed shaft is shown in fig. 124. In following this, several sets are removed near the bottom of the intended penthouse, and bearers are placed across the shaft at the ends to support the regular shaft timbering. Below these, further short round bearers are hitched into the walls, over which shorter logs are laid crosswise in the haulage ways. On these latter logs, a steel plate is bolted. In the ladder-way a steel door is provided, which is hinged to the plate.

In a frame-set shaft, either of the methods shown in figs. 125 and 126 may

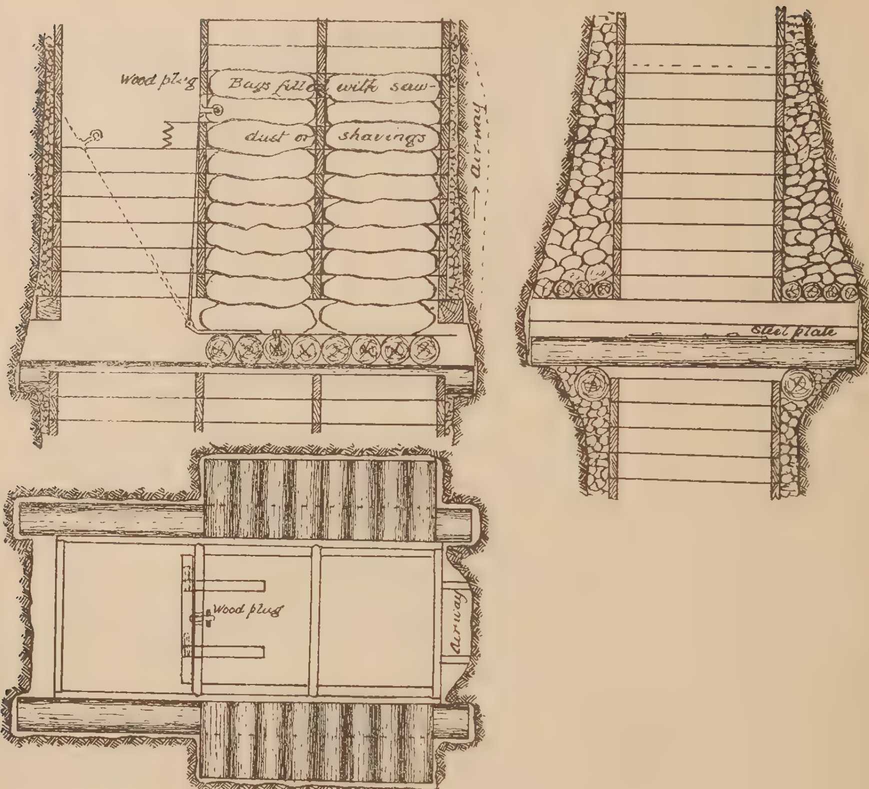


FIG. 124.—Penthouse in boxed shaft.

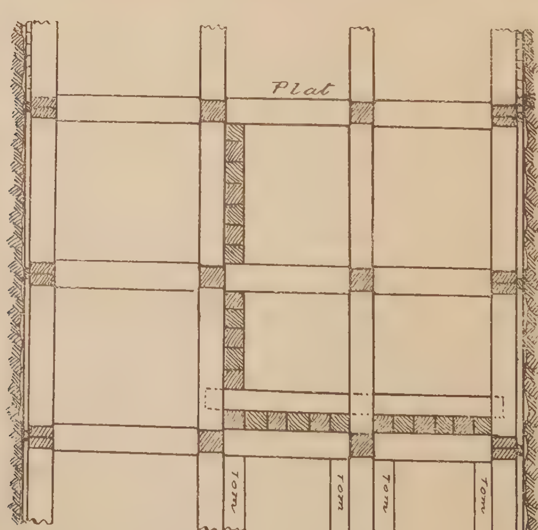


FIG. 125.—Penthouse in frame-set shaft.

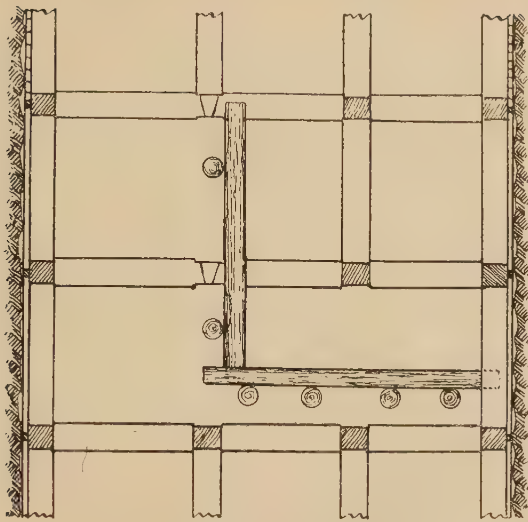


FIG. 126.—Penthouse in frame-set shaft.

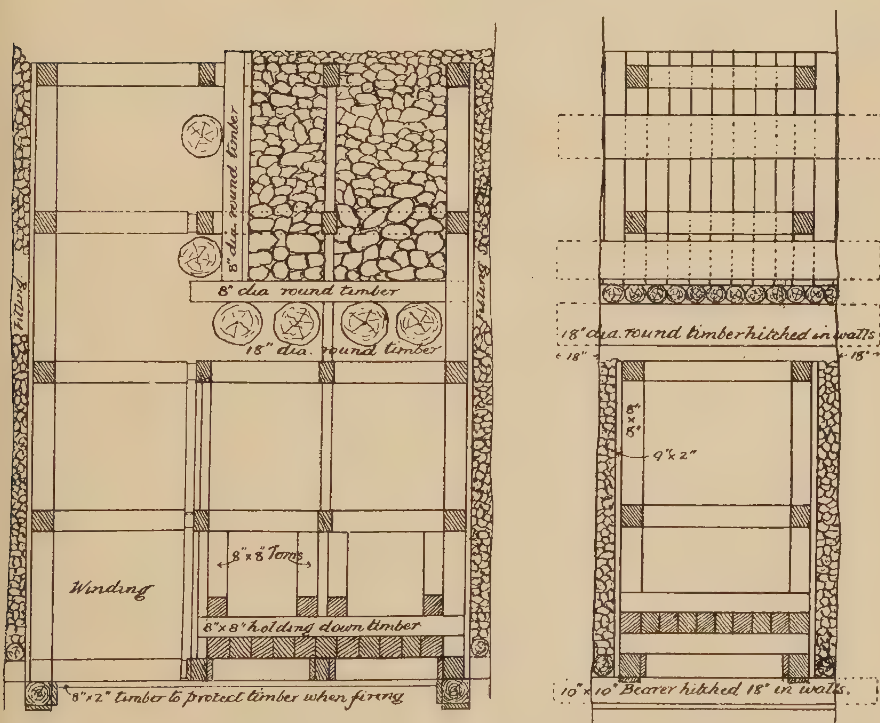


FIG. 127.—Penthouse in frame-set shaft.

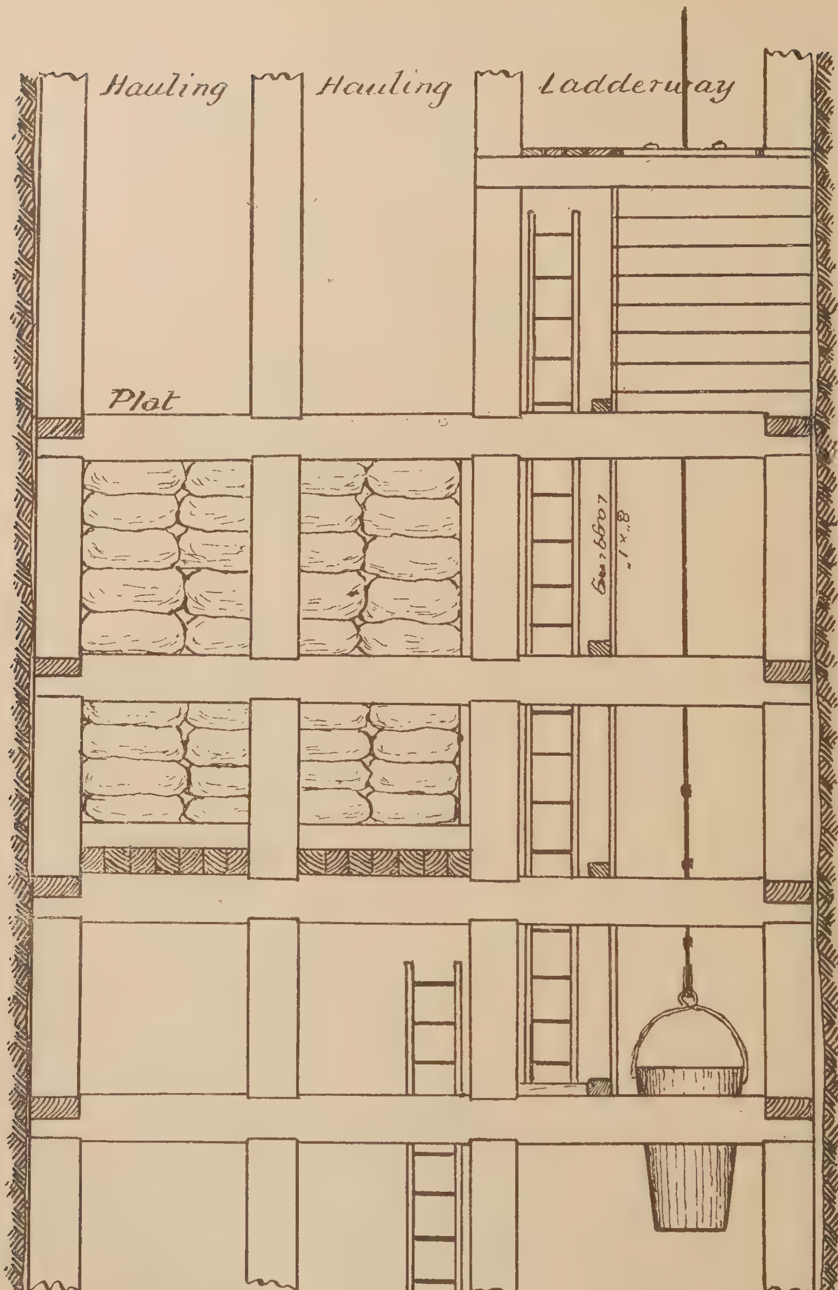


FIG. 128.—Showing method of providing ingress and egress for shaftmen while penthouse is in place.

be adopted. In the first of these 6-inch by 6-inch or 8-inch by 8-inch timbers are laid side by side across the wall-plates of the second or third set below the plat. On top of these a second layer of similar timbers is laid lengthwise with the shaft. If the ordinary partitioning is not considered strong enough to meet the requirements, further short timbers are laid one on top of the other, as shown, with their ends resting against the studdles, and the construction is then filled as usual with some approved material.

If thought necessary to strengthen it against the extra weight put on it by the penthouse, toms are placed under the frame-set on which the penthouse is built.

The method shown in fig. 126 aims at relieving the shaft timber altogether of the weight of the penthouse. At a suitable distance below the plat, logs of from 12-inch to 18-inch diameter are hitched into the walls between two of the regular shaft sets, and also on the side adjoining the ladder-way. Squared timbers of 8-inch by 8-inch material are then laid over the bottom logs and against the side logs. To enable these side logs to be put into position, the studdles and partitioning of the frame-sets within which the penthouse is built have to be removed.

In a shaft where the rock in which the sinking is being carried out is very hard, and the use of heavy charges in blasting is necessary, a combination of the two foregoing methods is sometimes employed, as shown in fig. 127. In this case the lower part of the penthouse serves rather to protect the upper portion against damage from the blasting than assist in preventing anything falling into the shaft from above. This illustration, together with those shown in figs. 122 to 124, are taken from E. D. Cleland's *Western Australia Mining Practice*, in which work the various methods are mentioned as being all more or less made use of in that State.

In fig. 128 a general idea is given of the usual manner in which the men employed in sinking the shaft are provided with safe ingress and egress to and from their working places. A portion of the sinking compartment, just sufficiently wide to allow a man to pass, is closed off to a depth of at least one set below the bottom of the penthouse. In this closed-off portion a ladder is provided. From this point down, the ladders are placed temporarily in the next compartment. This arrangement prevents any possibility of the men, when ascending or descending, being struck by the sinking bucket. When the lift has been completed, all the ladders are removed, and set permanently in the ladder-way.

CHAPTER VI.

TIMBERING LEVELS.

In timbering the crosscuts, drives, etc., constituting a level, great variety is introduced, the particular method adopted being determined by such factors as the width of the ore deposit, the nature of the walls, the cost of timber, and the class of timber available.

TIMBERING DRIVES IN NARROW LODES.

When a mine is small, with ore-shoots of no great length or width, very primitive ways of securing the drives may be employed with satisfactory results. One of these is shown in fig. 129, and merely consists in cutting away part of the foot-wall, and standing up against it what may be termed vertical stulls. The foot of each is set in a hitch cut in the drive floor, and the top rests on the foot-wall. Behind these uprights a lacing of laths or poles is placed to retain such filling as may be required. This method is only applicable when the walls of the lode are fairly strong, and their dip approximates 40 degrees.

Fig. 129.—Timbering drive on narrow vein.

In small workings of this kind the more common method of forming a drive, under the conditions mentioned, is that of putting in stulls as shown in fig. 130. The lower end of each stull is hitched into the foot-wall at the desired height, usually about 5 feet at least from the floor, while the upper end rests against a head-board placed against the hanging-wall. The purpose of the head-board is to give the stull a larger bearing surface on the wall. A stull used in this manner is never set at a right angle to the hanging-wall; if it were, the least pressure from above, or any slight movement of the wall, would cause it to fall out; it is therefore set at an angle which may be roughly given as about one-fourth that of the angle of dip of the wall. The end of the stull resting on the head-board is cut to a bevel so as to bear fully on the latter. To get the correct angle for the bevel, a form of template such as shown in fig. 131 is used. Stulls are usually placed at from 4-foot 6-inch to 5-foot centres, and are about

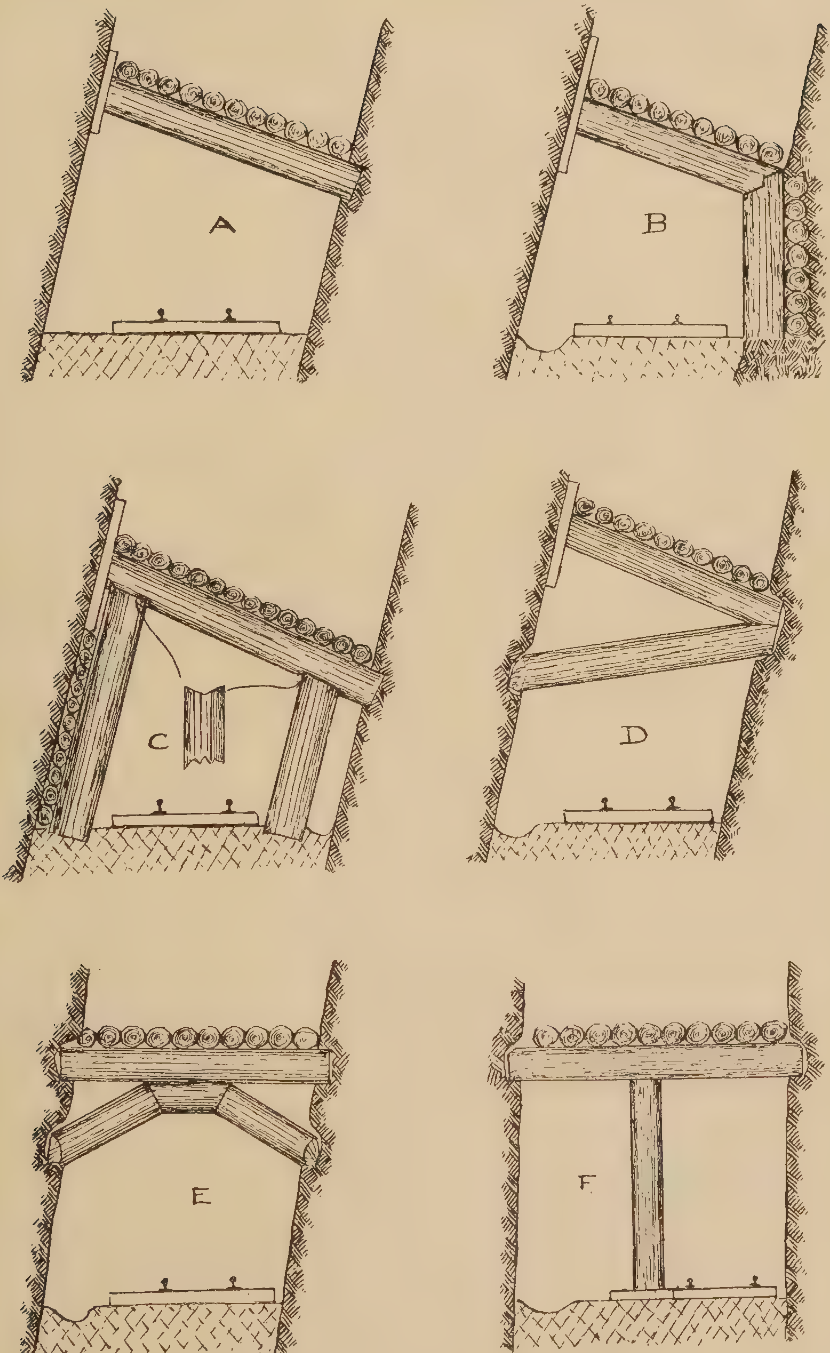


FIG. 130.—Various adaptations of stull timbering for drives.

7 feet 6 inches to 8 feet above the rails on the high side. Before they can be put in place plenty of headroom must be provided. The ordinary practice is to put the drive through first without timber, then to come back and take the leading stope off, the stulls being put in as the latter work progresses.

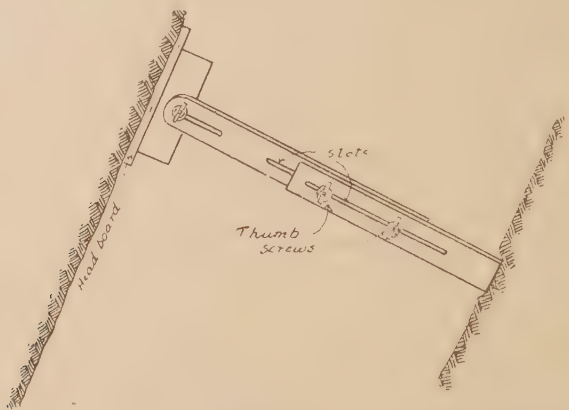


FIG. 131.—Template used to enable stulls to be cut to right bevel and length.

A number of variations on this stulling method have been employed to meet differing conditions. Thus, in cases where the hanging-wall is firm but the foot-wall friable, each of the methods shown at B, C, D, E, and F (fig. 130) have been more or less made use of. In the first of these, part of the foot-wall is trimmed

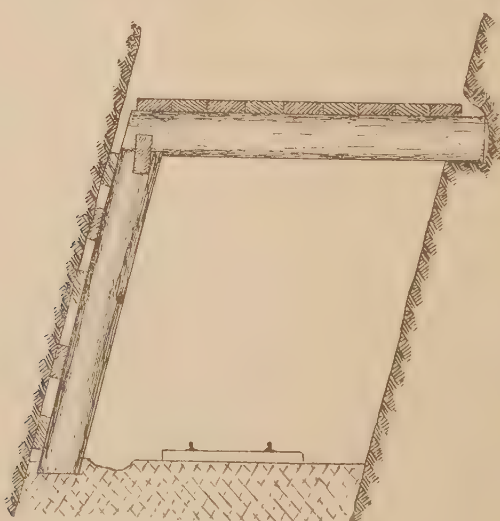


FIG. 132.—Two-piece drive-set (half-set).

away, and a leg, joggled in some suitable way at its upper end, is stood, on which the lower end of the stull rests. In method C, two *toms* (known also as *deadmen* or *soldiers*), collared at their upper ends, are placed under the stull, one at each end, practically making a three-piece set. In method D a false

stull is inserted under the stull proper in such a way that the downward thrust of the latter against a weak foot-wall is changed into a diagonal thrust against the stronger hanging-wall. Methods E and F are more suitable for use in a drive with fairly good walls but a weak back, when it is not intended to take off a leading stope. The stulls are hitched into the walls close to the back of the drive, and in a horizontal position, the saddle-back or *tom* being used to give it greater strength. In drives of this kind, however, or in cases where the foot-wall is fairly strong but the hanging-wall is so weak as to make it inadvisable to take off a leading stope without timber of some kind being first put in, a method of timbering frequently adopted is that shown in fig. 132. This consists in standing a leg on the hanging-wall side, on which one end of a cap-piece rests in a joggle, the other end being hitched into the foot-wall. The method is commonly known to miners as timbering by half-sets.

In drives where both walls are weak, or where more or less serious pressure

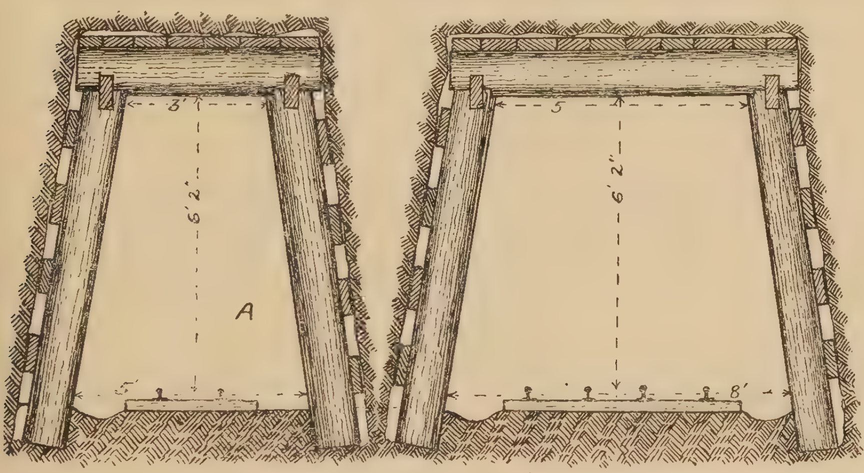


FIG. 133.—Ordinary three-piece drive-set.

may later on be expected from the sides, the use of three-piece or four-piece sets, as shown at A (figs. 133 and 134), becomes necessary. In most of the quartz mines of the Reefton field in New Zealand, where the gold-bearing veins are often very narrow—in the Blackwater Mine the average width is only about 20 inches—but both walls are decidedly weak, the type of set shown at A (fig. 133) is the standard timbering. Round beech timber of from 12 inches to 16 inches diameter is used. The legs are 7 feet long, and are let into hitches cut in the drive floor. The cap is 3 feet to 3 feet 6 inches between joggles, and the spread of the legs at the level of the rails 5 feet to 5 feet 6 inches. Considerable pressure is exerted by the walls in these mines, particularly when stoping has extended up a short distance above the back of the level, and the legs of the sets are readily forced into the drive, nevertheless sills are never used with the sets. The principal reason for this is that the best of the local timber is of brittle nature, and if sills or bottom spreaders are used the legs are quickly broken and rendered useless, whereas if they are merely allowed to be forced into the drive they can, without great difficulty, be restored to their original position and made to give much further service.

In lay-bys on a single truck-road, or in somewhat larger mines where a double truck-road is a necessity, the wider sets shown at B (figs. 133 and 134)

are used. The central *tom* or *soldier* shown in the latter is not often required, but where much pressure is exerted from the back of the drive it will be found to serve a useful purpose. Fig. 135 shows a set used largely in gangways in the South Broken Hill Mine, New South Wales, in which wide ore-bodies were

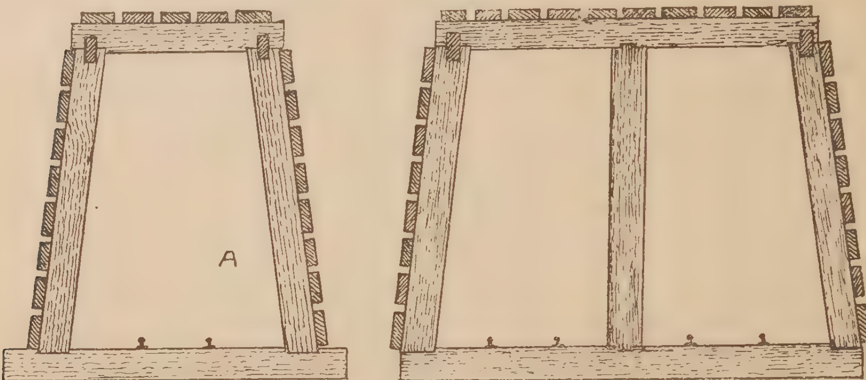


FIG. 134.—Four-piece drive-set for single and double roadways.

mined. Here the sill-piece was used, and in wide lodes it may be said its employment is nearly always advisable. Under such conditions, the pressures from the sides on the set timbers are usually less than they are in narrow lodes where the walls bear directly on them. In a wide lode, filling is introduced

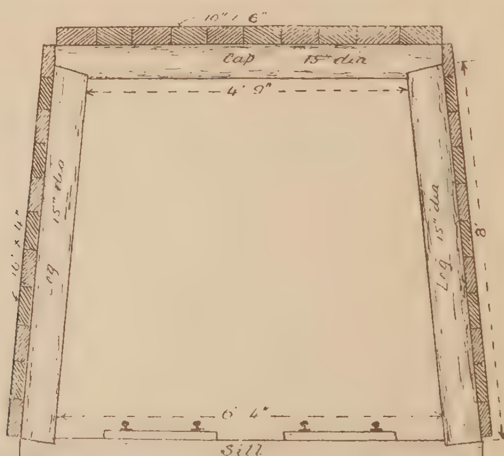


FIG. 135.—Standard set used in gangways, South Mine, Broken Hill, N.S.W.

between the drive and the walls, and this acts as a sort of cushion. The greatest pressure on the drive comes, in such a lode, from the back, and the chief use of the sill is to prevent the legs being driven downwards, a purpose in which they help to a material degree.

Joints for Drive-Sets. In the jointing of three- and four-piece sets many methods are in common use. Fig. 136 shows a number of ways of making the joint between cap and legs, all of which will give satisfaction under suitable conditions. It may be said that it is always a bad plan to cut away any more

of the timber in joggling than is absolutely necessary. If any splitting of the timbers takes place, it is usually along the lines of the cuts made in framing,

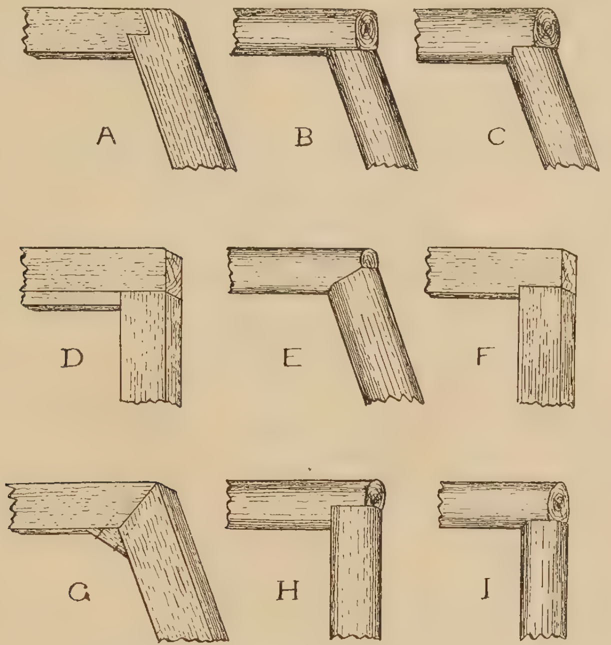


FIG. 136.—Post and cap joints for drive-sets.

and it stands to reason that the deeper these cuts are the more the timber is weakened, and the more likely it is to split. For this reason, joints A and H are to be avoided whenever any serious pressures are to be expected from back or sides. The joint in most general use is probably that shown at B, where the leg is left intact and only a slight joggle of 1 inch or $1\frac{1}{2}$ inch is made in the cap. When only an inferior class of timber is available, this shallow check in the cap offers no great resistance to side pressure, but if a spreader is put in between the legs immediately under the cap any danger of the legs being forced in will be minimised. The framing shown at D is perhaps the strongest of all those illustrated, for the full strength of the timber is retained. In using it, whatever side pressure there may be is exerted wholly against the spreader, and if this is crushed it is an easy matter to jack the legs back into position and put a new spreader in.

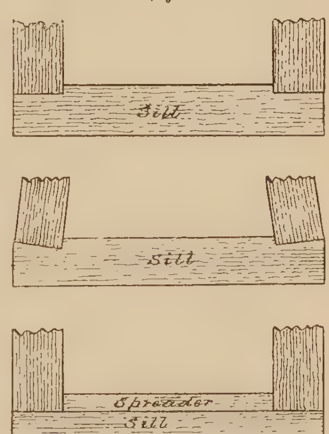


FIG. 137.—Post and sill joints for drive-sets.

In the jointing between leg and sill there is less variety, the three framings shown in fig. 137 representing practically all the methods in anything like common use.

Method of Erecting Sets.—The ordinary method of standing three-piece

or four-piece sets of the type shown in fig. 133 is illustrated in fig. 138. When sufficient ground has been removed to admit a set, the hitches are cut for the two legs, a measuring staff equal in length to the latter being used to ensure that the hitches are of the right depth, and that enough of the back has been removed to allow the cap to go into place freely. One of the legs of the new

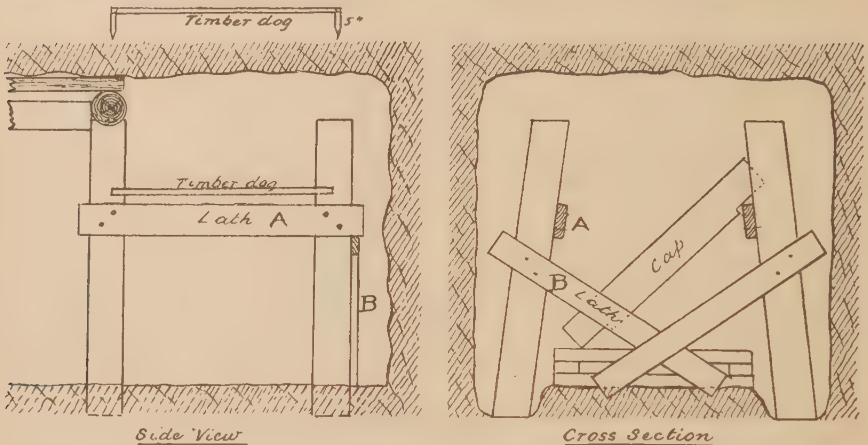


FIG. 138.—Showing method of erecting ordinary drive-set.

set is then stood, and secured approximately in position by means of the temporary stays A and B. Instead of A an iron dog may be used, as shown. The other leg is then stood and secured in the same manner. Two men now get the cap up into place by proceeding as follows: One end of the cap is first lifted up and rested against the temporary stay A. If the set is unusually

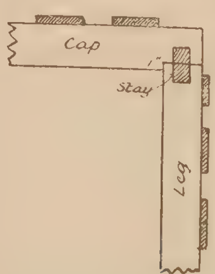


FIG. 139.—Post and cap joint, showing position of stay.

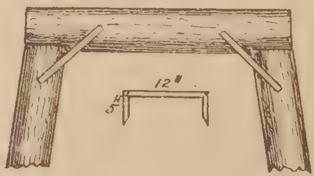


FIG. 140.—Showing method of securing drive timbers with iron dogs.

high, a stage formed of laths may first be built on which the lower end of the cap rests. This lower end is next lifted and placed on the stay A, on the other side of the drive. A second lift is then made at the end of the cap first lifted, and it is placed on top of its leg, after which it is an easy matter to lift the other end to its permanent position. Once the cap is in place, the set is aligned, laths are placed over the back, and wedges driven to prevent any subsequent movement. The side laths are next put in, and any spaces between them and the walls filled with waste.

To further lessen any danger of either the legs or cap being thrust backward as the result of blasting in the face of the drive, stays are set between them and

those of the previous set, as shown in fig. 139, in such a way as to catch both leg and cap of each set. If thought necessary, a further stay may be placed about half-way down the leg. These stays are usually secured by drift-nailing. As an additional protection to the cap, the practice obtains in some mining districts of temporarily driving iron dogs in leg and cap on the side facing the blasting, as shown in fig. 140, but if the set is properly wedged and packed after being stood, this precaution is seldom called for.

TIMBERING ON CURVES.

Whatever type of set-timbering is used, the approved practice is to make each set conform as far as possible to the radius of any curve it may be necessary to give to the drive. When opening up a narrow vein, the invariable custom is to follow the ore whichever way it may turn, and as few mineral deposits strike in anything like a mathematical line, the result is that numerous curves

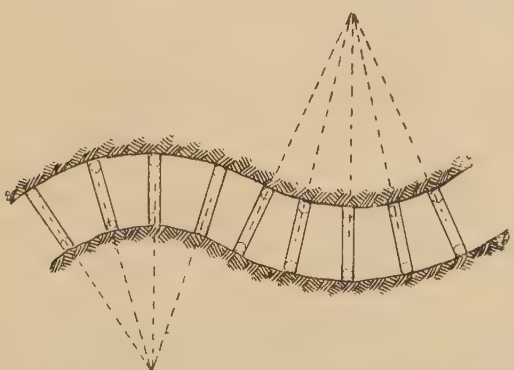


FIG. 141.—Timbering at curves in drives.

appear in the levels. When timbering around these, the sets are stood as in fig. 141. As far as possible the spacing of the legs on the outer side of the curve is kept uniform with that of the ordinary sets, that of the legs on the inner side being shortened to the radius of the curve. One reason making this course practically compulsory is that its adoption enables the regular width of the drive to be maintained without any necessity for lengthening the caps, and another is that by following it the sets are stood at something approaching a right angle to the probable line of pressure from the walls, and are thus able to offer better resistance to it.

THE PENNING SYSTEM.

A somewhat unusual way of timbering a drive on a small vein dipping at a flat angle is shown in fig. 142. This method is known as penning, and consists in cutting away portion of both foot- and hanging-wall, and erecting small cribs, over which stout poles are placed at intervals transversely to the line of the drive, these again being laced over longitudinally with the drive with laths or poles. The cribs as erected are filled with large waste. There may be some circumstances, such as that where a heavy hanging-wall is more than usually destructive to ordinary set timbers, when this method may be

useful, but in general it may be said that it has little to recommend it; it certainly calls for the employment of a much greater amount of timber than

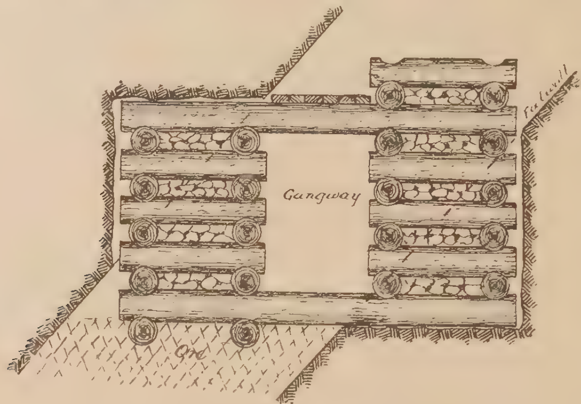


FIG. 142.—Penning method of forming gangway in narrow flat lode.

would be necessary when using regular sets, and the cost of placing the cribs in position would also be greater than that of standing sets.

DRIVES IN MEDIUM TO WIDE LODES.

The use of stull timbering is not limited to drives on narrow lodes. What may be described as the single-stull method has been employed with success

FIG. 143.—Long stulls supported by *toms*.

in timbering trucking ways in lodes up to 25 feet or more in width, and what is known as the battery-stull system, a description of which will be found in the section of this volume dealing with the timbering of overhand stopes, has

been used satisfactorily in even wider lodes. When long single stulls are used it is, however, advisable to support them near the centre with a *tom*. The half-set may also be employed in timbering openings up to 20 feet or even 25 feet in width, but a prop, as in fig. 143, must be placed under the cap to help it support the back weight that must inevitably come on it from the stope-filling.

For lodes of the width mentioned, other variations on the stulling system, such as shown in fig. 144, have also been tried with more or less success. In the lower of these, the set represents what may be described as a stull reinforced

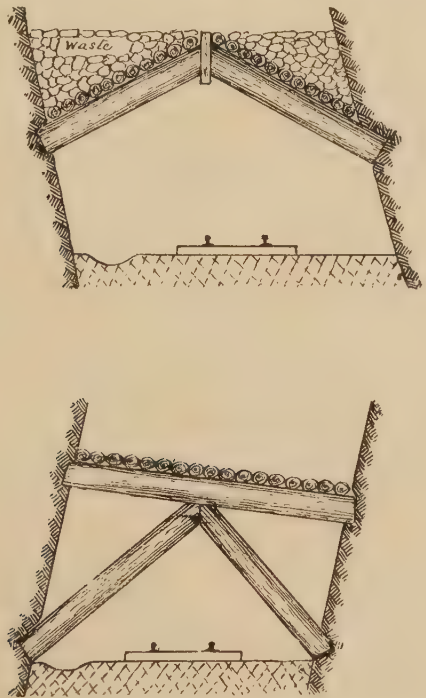


Fig. 144.—Examples of saddleback drive-timbering.

by a saddleback, and in the upper a saddleback proper. The use of such methods of timbering is now seldom resorted to. They call for a good deal of skill and care on the part of the workmen in preparing and standing the timber, and are thus rather costly under present-day mining conditions; further, they offer no result so greatly superior to the simpler modern methods as to warrant their adoption.

In most of the New Zealand mines in which the width of the ore-body exceeds 8 feet to 10 feet, the drives are almost invariably timbered as shown in fig. 145, with a combination of what are termed *king-posts* and caps. The ore may be much wider than 10 feet, but whatever its width may be, a lateral extension of this class of timbering meets all requirements. In timbering in this way it is not customary to first put out the drive and timber it, and subsequently wing off the sides; the whole width of the ore-body is taken out in the driving operation, and the sets are stood both in the order of advance and laterally as soon as room is made for them. One run of sets in the most suitable

position is selected as a trucking- or gang-way; this is lathed up, and filling placed on either side. The position of stays is not shown in the illustration, but each line of sets, as it is erected across the lode, is stayed well to the line behind it.

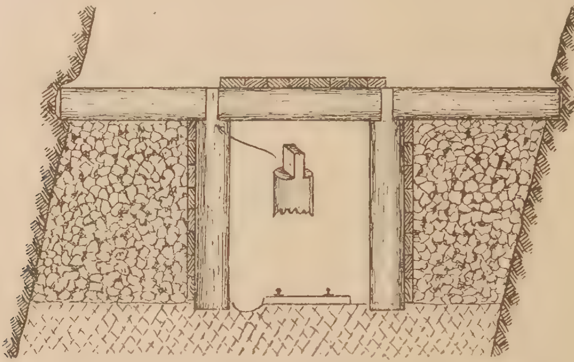


FIG. 145.—King-post and cap timbering for drive in wide lode.

In fig. 146 a method of drive timbering is shown that was employed to a great extent in the old Cobar copperfield in New South Wales. The lodes were fairly homogeneous, and were stripped from wall to wall. In a suitable

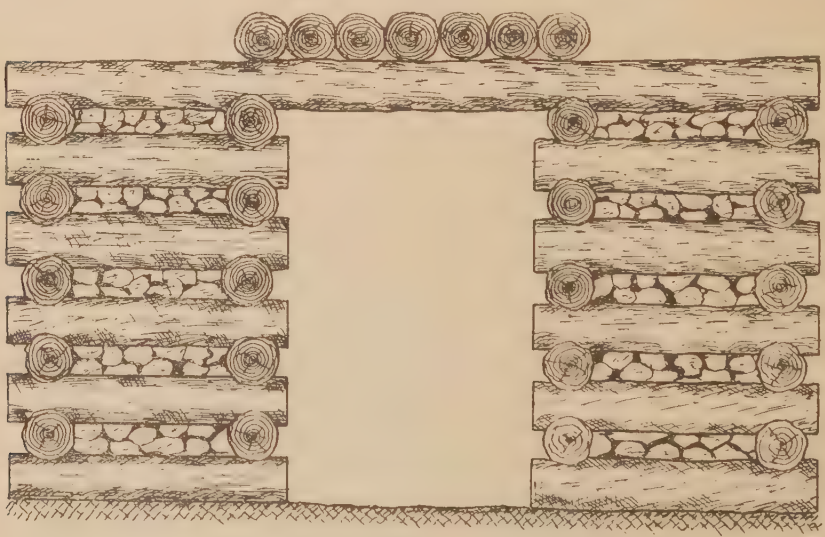


FIG. 146.—Forming drive by use of cribs or pigstyes.

position, which might be either on the central line of the strike of the lode, or towards one wall or the other, rows of cribs, from 7 feet to 8 feet on the square, were built up to a height of about 7 feet. Across each pair of cribs logs of sufficient length to span well across the drive were placed, and on these again poles of any suitable length to form a back. Further poles were then laid to form a floor between the cribs and the walls, and filling was poured in to replace the deleted ore.

GANGWAYS IN VERY WIDE LODES.

In timbering trucking-ways in very wide lodes, such as, for instance, those of the Broken Hill Mines in New South Wales, where a tremendous weight of filling has to be carried by the timber, sets such as shown in figs. 147 and 148

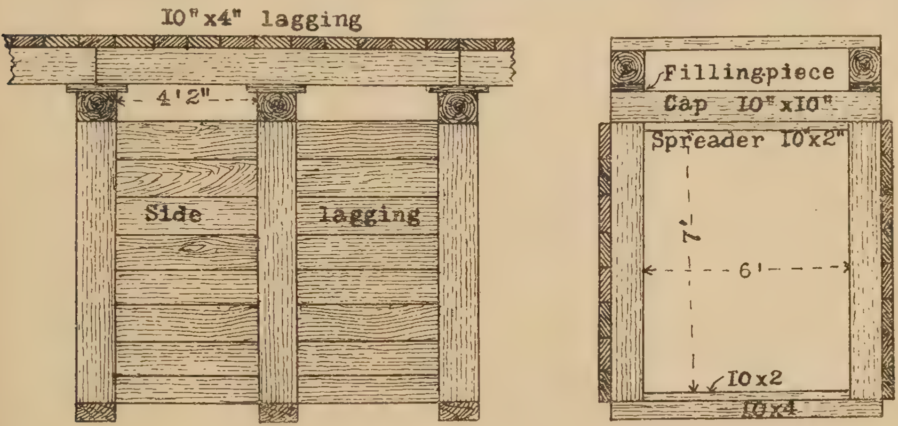


FIG. 147.—Drive-timbering, South Blocks Mine, Broken Hill, N.S.W.

are used. The arrangement shown in the former was for years the standard method in the South Blocks Mine on that field. It will be noted that each set was stood on an independent sill, and that over the ordinary caps further

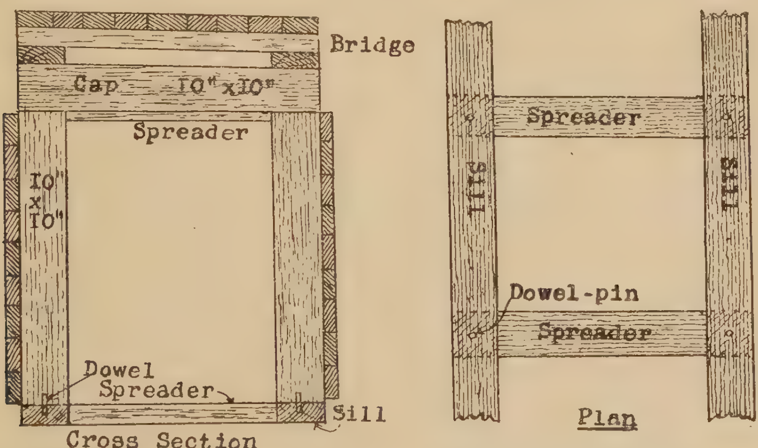


FIG. 148.—Gangway-timbering, North Mine, Broken Hill, N.S.W.

longitudinal caps were placed. No joggles were cut in either leg or cap, spreaders being used to keep the legs apart.

The method shown in fig. 148 was followed to some extent at the North Broken Hill Mine. In this case the sills, instead of being placed across the gangway at each set, were laid longitudinally in lengths sufficient to carry from three to four sets, spreaders being placed between them at each set-

interval. Iron dowel-pins, which entered the sill and the bottom of each leg, assisted in keeping the latter in correct position.

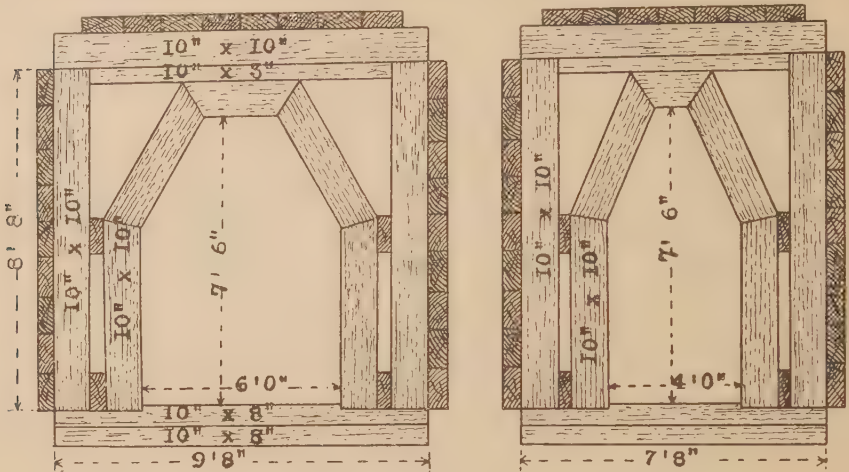


FIG. 149.—Broken Hill drive-sets used in heavy ground.

When extra heavy pressures were anticipated, reinforced sets, such as shown in fig. 149, were used for double or single roadways respectively. These sets were used chiefly in workings where the spaces on either side, between the drive and the walls, were to be filled with waste.

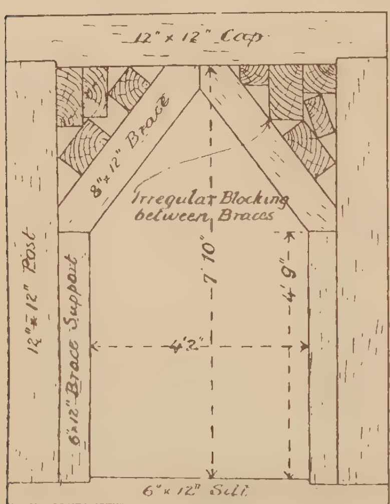


FIG. 150.—Angle-braced drive-timbering, Ruth Mine, Nevada, U.S.A.

In fig. 150 the framing of a set is shown, which resembles to a great degree that of the set illustrated in the previous figure. This was used under somewhat similar circumstances in the Ruth Mine, Nevada, U.S.A. The irregular blocking above the braces extended from set to set, and served the purpose of stiffening the timber as a whole.

In cases where gangway timbers are intended to form an integral part of a general square-set stoping system, other ways of framing the sets have to be adopted. One of these, which was used in forming double-width roadways in the Mount Morgan Mine, Queensland, Australia, is shown in fig. 151. The usual stope-sets were of squared timber, but for the legs and caps of the gangway-sets round timber of up to 18 inches diameter was employed. Over the cap of the set ordinary lagging was placed, on top of which was laid what may be termed a second cap, the purpose of which was to assist the cap proper by taking up some of the weight of the superincumbent stoping sets, and of the filling that would subsequently be introduced.

Further methods of preparing and fixing gangway-sets in large square-setted mines are indicated in figs. 196 to 207 in the section of this volume

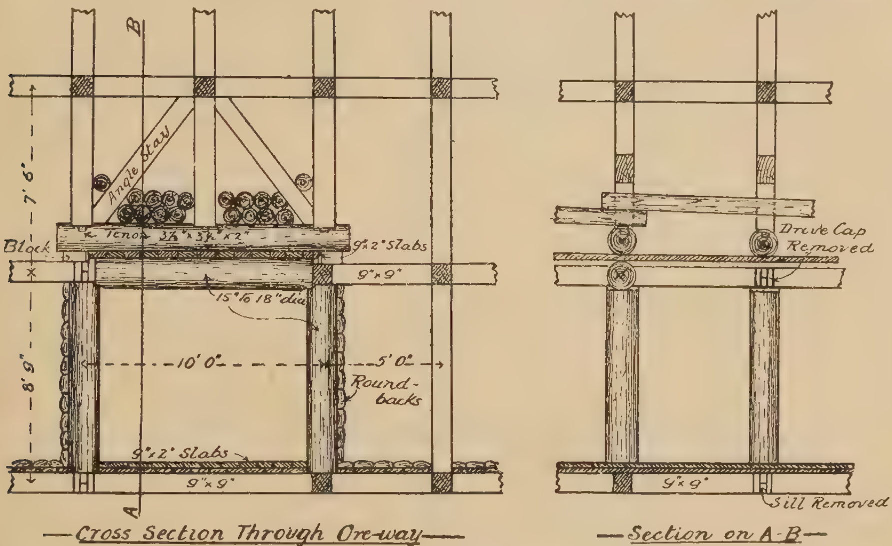


FIG. 151.—Timbered gangway in wide lode, Mt. Morgan Mine, Queensland.

dealing with overhand stoping on the square-set system, and for detailed information regarding them the reader is referred to the text accompanying those illustrations.

TIMBERING DRIVES IN HEAVY OR SWELLING GROUND.

The enormous destruction of timber, and cost of maintaining levels, in mines in which serious pressures are exerted by walls, back, or floor, can scarcely be realised save by mining men of wide experience. In nearly all mining countries there are districts in which trouble from this cause has been a grave handicap on the mining industry. In localities where the supply of timber has been plentiful and cheap, it has been possible to cope with the trouble to some reasonable degree by merely removing the swelling ground, and replacing broken sets as occasion demanded, but where this condition did not prevail much ingenuity has been called for on the part of mine-managers in the effort to protect levels from injury, and keep work going along without undue interruption.

In cases when the pressure is mainly from the walls, and exerted slowly, the use of a sill may help considerably in preventing displacement of the sets. In lieu of the regular sill, the dropping in of a spreader in the manner shown in fig. 152 has occasionally been found to give satisfactory results. Sills or spreaders can only be used, however, when timber of good quality is employed in the sets; with brittle timber their use may do more harm than good, for the resistance offered to the inward thrust of the legs merely leads to the latter being broken more readily than would otherwise be the case.

Instead of allowing the side laths to rest directly on the legs of the sets, the plan is at times adopted in similar circumstances of placing short tapered

pins or pegs between the laths and the legs as at B (fig. 152). When pressure comes, the laths are forced on to the pegs, thus easing to some extent pressure on the legs. When the laths have been thrust inward to the legs, they are

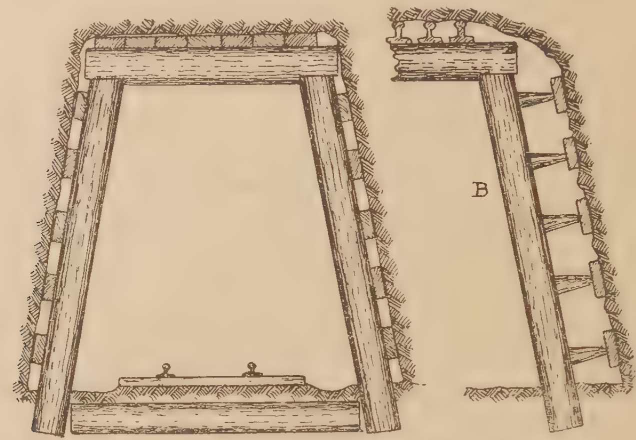


FIG. 152.—Ordinary three-piece drive-set, with spreader.

removed, and fresh laths and pins put in. Occasionally, also, old iron rails are used over the backs in place of timber.

In mines where the trouble has been chiefly caused by rapid swelling of the sides, combined perhaps with the presence of a soft swelling floor or bedrock,

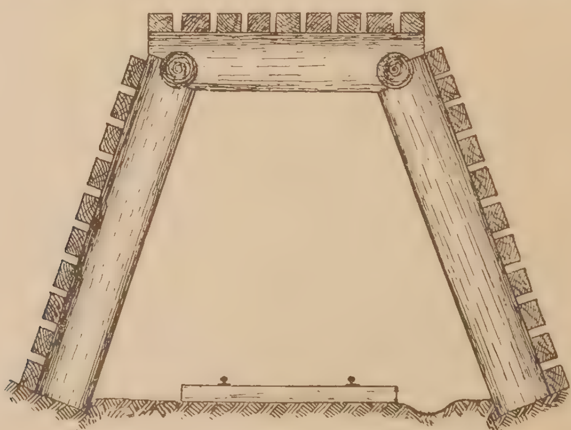


FIG. 153.—Set with wide bottom-spread, to resist side pressures.

one of the most effective means of coping with it has been found to be the giving of a greater spread to the legs at the bottom than is usual or necessary under other circumstances, as shown in fig. 153. In the Mother-lode region of California, excessive pressure against the timber by swelling ground was a common feature in lode mines, whilst swelling bedrock was a frequent cause of trouble in the alluvial (drift) mines. After much costly experimenting it was found that the only way of dealing at all satisfactorily with the difficulties that arose was to use as heavy timber as possible, up to 20 inches or more in

diameter, giving the legs a wide lateral spread, and easing the sets frequently by digging away the swelling ground. This method of timbering drives was followed in the Hidden Treasure Mine, Placer County, Cal., and Ross (59), referring to it, says that while the pressure of the ground was not great, swelling bedrock was a source of trouble, driving the legs of the timber-sets inwards and crushing the cap. After many unsuccessful attempts to overcome this difficulty, the legs were given an increasingly greater bottom spread, until finally it was found that they remained stationary. The swelling bedrock was removed from time to time, and the track adjusted. The sets were first put in 4 feet apart, and a few months later intermediate sets were placed between them. After the sets had been in for three years they were still in good condition.

A variation on this method is shown in fig. 154, and is mentioned by Storms (12) as having been adopted by Richard Rowlands, a mining engineer of Placerville, California, in timbering a drive in heavy running ground in Sierra County,

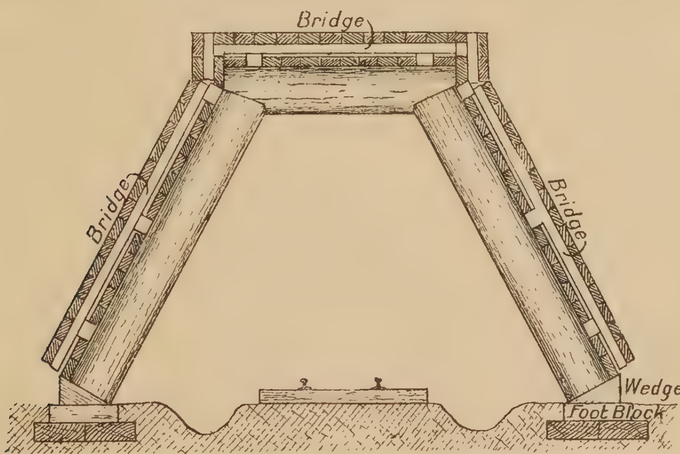


FIG. 154.—Californian method of standing drive-sets in swelling ground.

California. This consisted in standing the legs of the sets on wedge-shaped blocks which in turn rested upon double, flat foot-blocks, placed at right angles to each other. The foot-blocks served the purpose of giving the legs a broad and firm support on the swelling bedrock, and the object of the wedge-blocks was to prevent any tendency of the legs to take on an undue amount of spread. Experience seemed to show that sets once placed in this way did not afterwards shift.

The same well-known writer on mining matters, W. H. Storms, dealing with drift mines at Sugar Loaf Mountain, Nevada, California, where similar trouble from swelling ground was experienced, states that after much experimenting the method shown in fig. 155 was finally adopted, and was found to answer every requirement, the timbers, once firmly placed, never again needing renewal. The plan was to first run in and timber a drive in the usual way, with sets 5 feet centre to centre, round timber of large diameter being used. A little later, triangular sections were cut out on each side of the drive between the legs of each two adjacent sets. In the apex of each triangle a further leg was stood, the centre of which was 3 feet outside the centre line of the ordinary sets. From the top of the new post to the tops of the two adjoining posts angle-caps

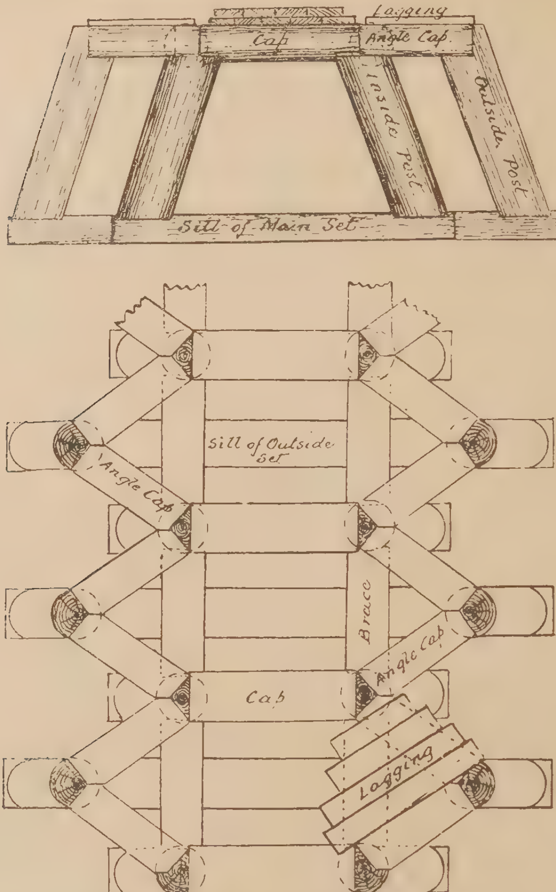


FIG. 155.—Another Californian method of timbering a drive in badly swelling ground.

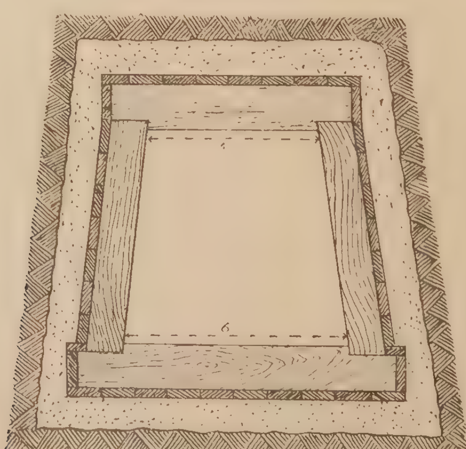


FIG. 156.—Drive-set used in very heavy ground, Langi Logan Mine, Victoria.

were placed. Lagging was then put in outside the legs and over the back in the triangles, plenty of space being allowed between the pieces to admit of the swelling ground forcing its way through. This method entailed much expense in mining and timbering, but it is said to have been so infinitely superior to any previously tried that it was looked upon as a success mechanically and financially.

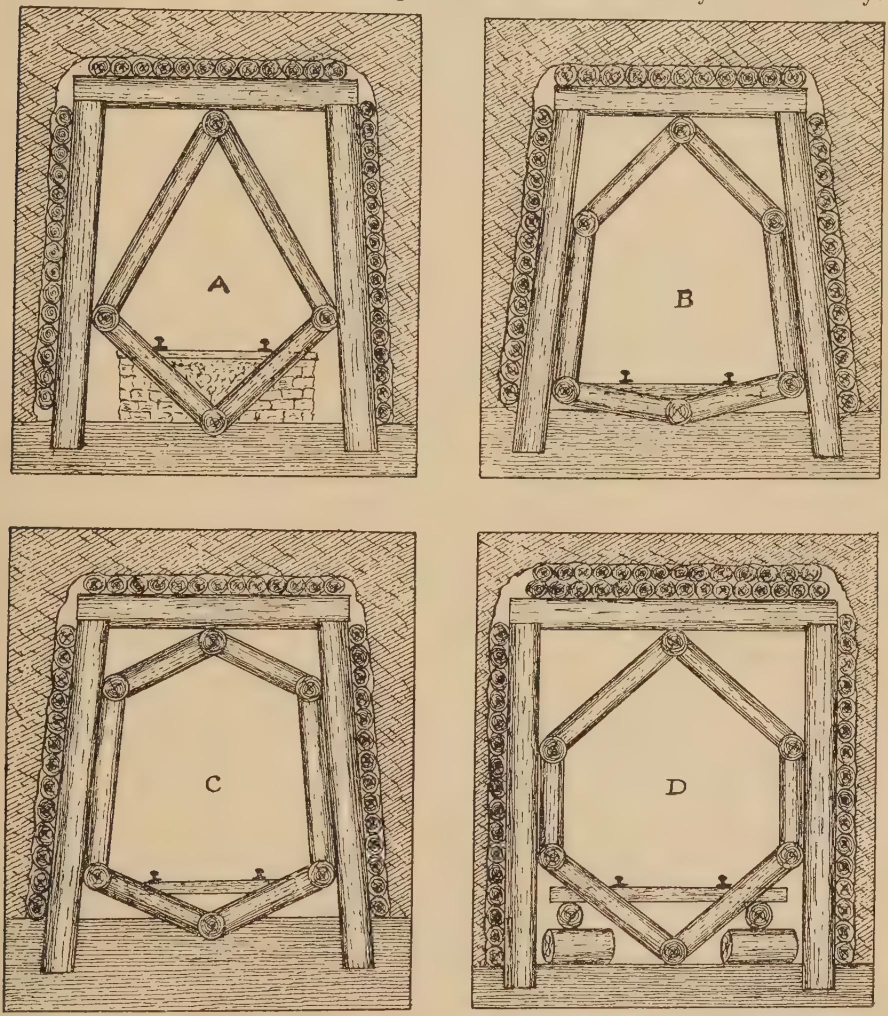


FIG. 157.—Methods used in Germany for strengthening drive-timbers in swelling ground.

Fig. 156 shows a method of timbering used in the Langi Logan Mine in Victoria, Australia, in a drive in which the ground swelled badly on exposure. With a view to excluding the air from the walls of the drive, the latter was cut out larger than usual; a layer of sand was then laid on the floor, on which 12-inch by 12-inch sills were bedded; as the sets were stood, they were lagged closely, and the sand filling was carried up the sides and over the back so that it formed a packing 12 inches thick all round between lagging and walls and roof. This method was not, however, relied upon wholly to protect the sets,

for when the drive had been carried in for some distance parallel drives were run in on either side of it, some 7 feet or 8 feet away, and supported with any rough timber that came to hand. The main drive is said to have subsequently stood without crushing, but how far this was due to the method of timbering is hard to say. In all probability it was due rather to the parallel drives, which gave the pressure of the ground opportunity to relieve itself.

In the Schwallbach Mines of the Saar district of Germany great pressure came on the timbers from the floor and sides, and three-piece sets were able to resist it for only a short time. In order to cope with the trouble the various methods of reinforcing the sets shown in fig. 157 were tried. Of these, method D gave the most satisfaction. With methods B and C the tendency was for the swelling floor to force the legs of the three-piece set apart when the lower angle-pieces of the reinforcing timbers were thrust upwards, as in fig. 158. By

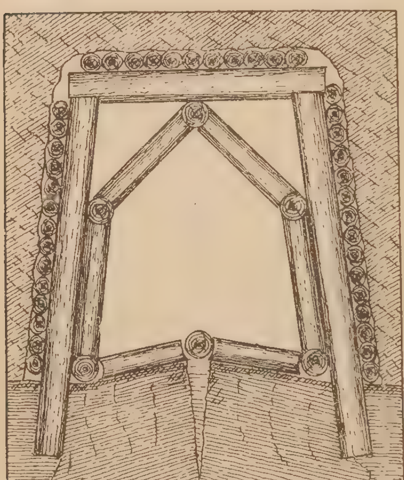


Fig. 158.—Illustrating effect of swelling bedrock on timbering shown at B in fig. 157.

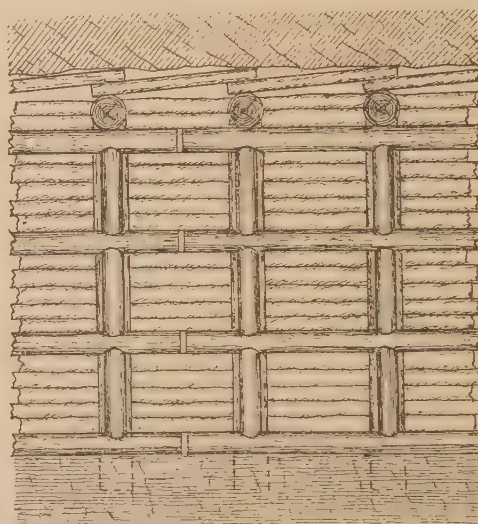


Fig. 159.—Longitudinal section of timbering shown at D, fig. 157.

pitching the floor braces at a greater angle, as at D (fig. 157), and standing the legs of the set almost vertically, it was found that much more resistance was offered by the timber as a whole to the pressure from the floor, with the consequence that the sets gave considerably longer service. It will be noted that small timber was used throughout, the sticks being about 6-inch diameter, and that the braces were separated from each other by longitudinal timbers. Fig. 159 represents a section along the drive of the timbering shown at D in fig. 157.

Drive timbers of a number of the types described are now rarely seen in mines, and most modern mining managers would be inclined to look askance at any proposal to adopt them, nevertheless they have been referred to as showing what has been done in various mining fields in the effort to cope with unusual and trying conditions. In a general way, it may be said that all such methods of drive timbering as shown in figs. 155 to 159 are of a nature calling for a good deal of skill on the part of the workmen in preparing and erecting the timbers, are rather costly, and can only be adopted as a last resort. When

all other simpler methods have been tried without satisfactory result, their use may be justified.

Provided that a good class of timber is available, it is heavy and difficult ground indeed in which a drive cannot be fairly well maintained by using the straight-out set timbering shown in, say, figs. 153 and 154. The giving of a good spread to the legs is a wise plan, and if the floor is soft the use of the foot-blocks and wedges will help considerably to prevent displacement or

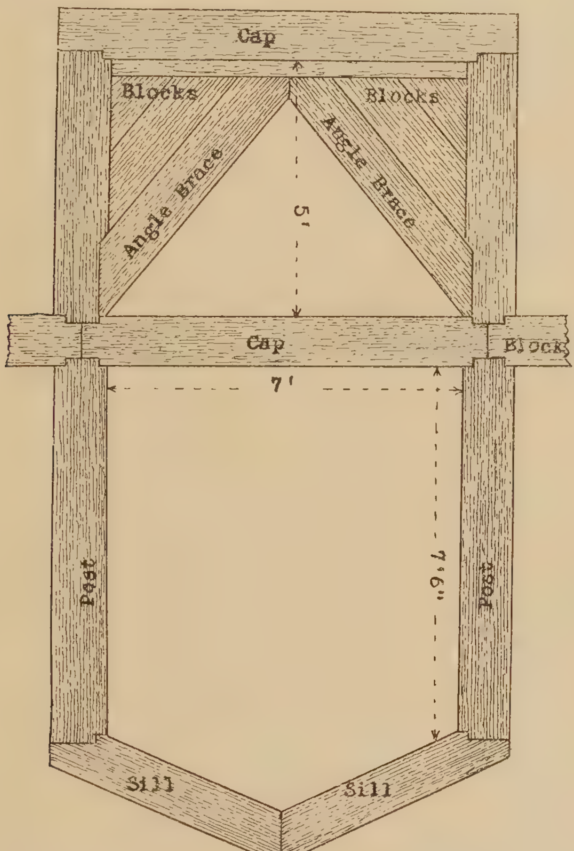


Fig. 160.—Gangway set, Ray Consolidated Mine, Butte, U.S.A.

sinking of the legs. A leg may be broken occasionally, but if care is exercised in removing the swelling ground from time to time trouble of this kind can be greatly lessened, and in any case it is questionable if it is not cheaper to renew the timbers as required than to adopt the other more intricate methods.

In the Ray Consolidated Mine at Butte, U.S.A., where a form of square-set timbering was employed, the tendency of the drive sets to be crushed led to the adoption of the method of framing shown in fig. 160. Instead of using a solid sill, as is usual in timbering with square-sets, a two-piece sill was put in, and by pitching the timbers at an angle such as shown the trouble was satisfactorily overcome.

TIMBERING DRIVES IN RUNNING GROUND.

The usual practice followed in advancing a drive in sand or in wet country liable to run, is to use the fore-poling method shown in fig. 161, and as the work is carried out in practically the same manner as that described previously in these pages as being followed when sinking shafts in similar ground no further detailed description of it is called for. Laths or poles are driven at the sides and over the back, a false set being used to keep them in place till sufficient ground has been removed to admit of standing a regular set, and breast-boards are placed against the face. Once a regular drive-set has been secured in position, the procedure in advancing for a further set is first to insert the points of the back laths over the cap, and under the bridge that has already been provided to admit of their entry, and drive them ahead as far as possible without using sufficient force to injure them. The front ends of the laths are trimmed off to wedge-shape to make the driving easy. The top side lath on

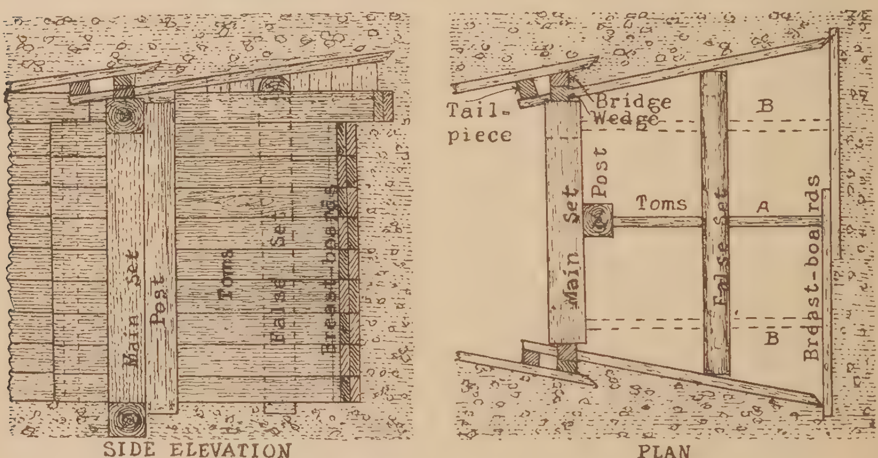


FIG. 161.—Timbering a drive in running ground.

either side is then entered, and they are driven as far as the back laths. Enough ground is now removed under the back laths to permit the first breast-board to be placed in. Another side lath on each side is entered and driven to the same distance as the first one, the ground is removed and a second breast-board put in, and so the work goes on till the whole of the laths on back and sides have been advanced to the same degree. If the ground is very bad, all laths will need to be driven as closely together as possible, and any spaces there may be in the upper corners between the side and back laths must be filled with short coping-boards. Owing to the inconvenience of handling long timbers at the face, the breast-boards are usually in two pieces, as shown, and as each pair is put in, the pieces are *tommed* back either as shown at A (fig. 161) to an upright stood in front of the centre of the last set, or else to the legs of the set, as at B. To avoid the use of the *toms*, the two-piece breast-boards are sometimes held together by thumbscrews, as in fig. 162. In this case one of the boards is provided with a slot cut lengthwise along its centre to admit of lengthening or shortening, as desired. When the laths have all been driven and the breast-boards advanced to somewhat more than half the regular set-interval, the false set is stood close up to the face. As this set only serves a temporary

purpose, the timber used in making it is much lighter than that of the ordinary sets. It is almost invariably given wider and higher overall dimensions than the regular sets, in order that it may stand firmly against the outward and upward-driven side and back laths. When the false-set is in place, the face is again steadily advanced until enough room is provided to stand a new regular

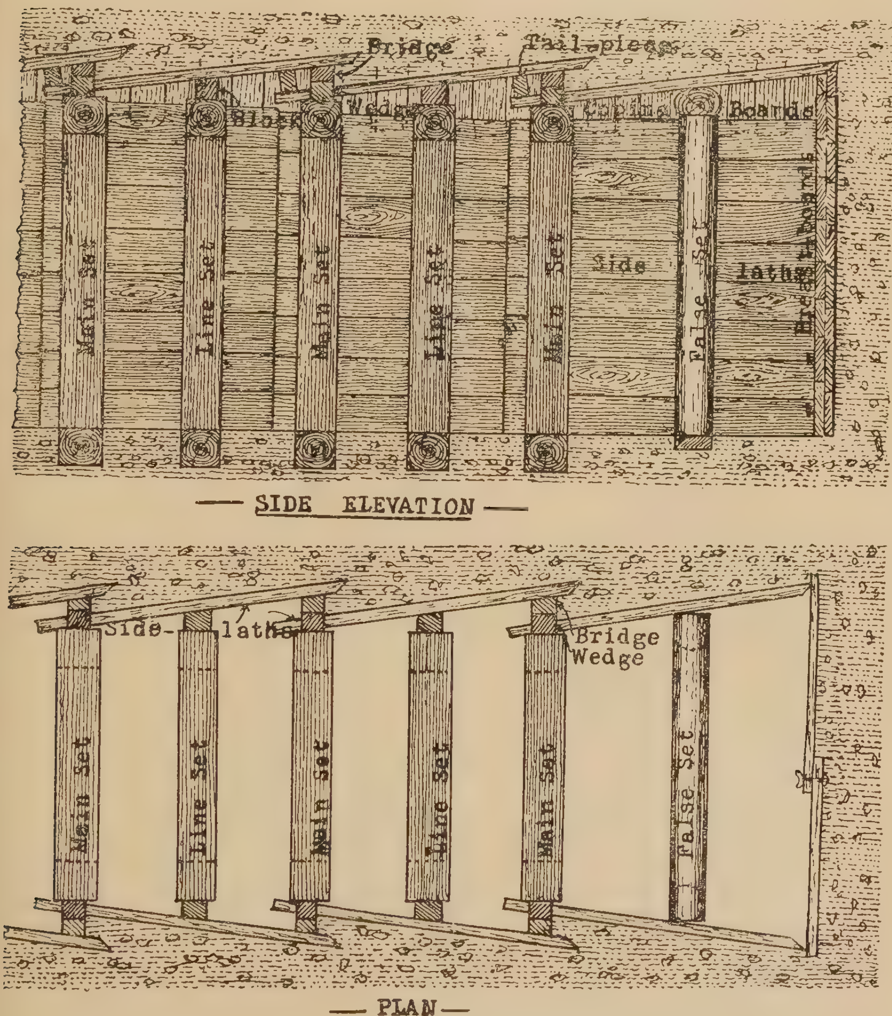


FIG. 162.—Another method of timbering a drive in running ground.

drive-set, and when the blocks and bridges have been placed in position around this, the false-set is knocked out, the laths are allowed to close in on the bridges, and the erection of the new set is complete.

Instead of using only one thumbscrew to hold the breast-boards together, as shown in fig. 162, it is common practice to use two screws, as in fig. 162A, and in all cases when the loose material being penetrated is likely to exert serious pressure against the timber it is advisable to follow this custom.

In some mining localities, where the ground is especially heavy, the false-sets are subsequently replaced with what are known as line-sets, as shown in fig. 162. When this course is followed, these additional sets are stood with their inner faces in alignment with those of the ordinary sets, any spaces that may be left between their outer faces and the laths being filled with small blocks.

FIG. 162A.—Breast-boards with two thumbscrews.

It is not by any means necessary that the legs of the drive-sets should, when fore-poling, be stood vertically. The work can be done just as conveniently and effectively if the legs are spread as in fig. 154.

Swinging False-Set.—In place of the ordinary false-set shown in figs. 161 and 162 the practice has been adopted in some American fields of using what is known as a "swinging" false-set such as shown in fig. 163, which is after an illustration in Robert Peele's *Mining Handbook*. It is claimed that in using this type of false-set the weight of the front ends of the laths or spilling can be

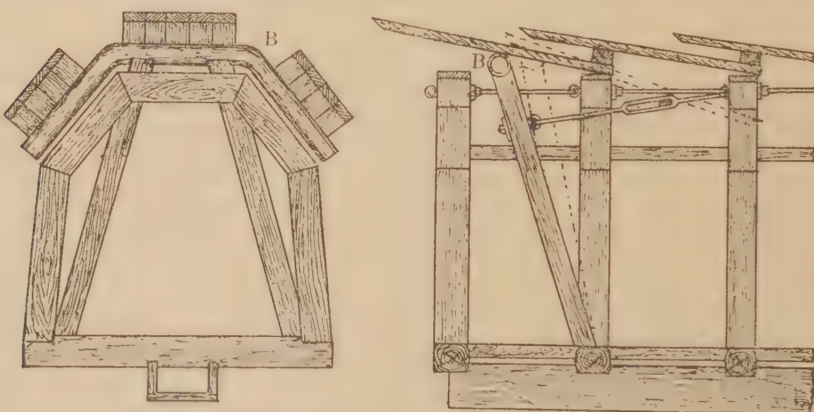


FIG. 163.—Illustrating a swinging false-set.

carried directly on it almost from the start, and that thus the laths can be driven with less hammering than is required when tail-pieces are employed. The posts of the swinging false-set carry a heavy steel pipe B which supports the front ends of the laths. As the latter are driven, the turnbuckles are slowly unscrewed allowing the laths over the back to gradually fall forward till they are nearly horizontal. When the laths are driven home, and the new set is in position, the turnbuckles are slackened off till the false-set loosens. The use of this swinging-set calls for the securing of at least several of the sets behind it with tie rods, but this is looked upon as an advantage, as by drawing these timbers back tightly against braces they can be wedged quicker and more effectively.

Flooring the Drive in Swelling Ground.—It is customary, when fore-poling, to floor the drive. If swelling of the floor is very rapid, short lengths of timber may be used at first to reach from main set to false-set, and from the latter to

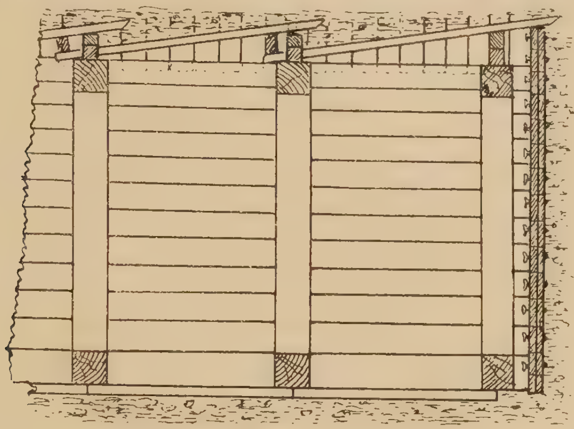


FIG. 164.—Flooring a drive in running ground.

the new main set. When the false-set has been removed, the short pieces may be replaced by full-length planks, which can be readily worked in under the sills of the main sets, when the appearance of the drive will be as shown in fig. 164.

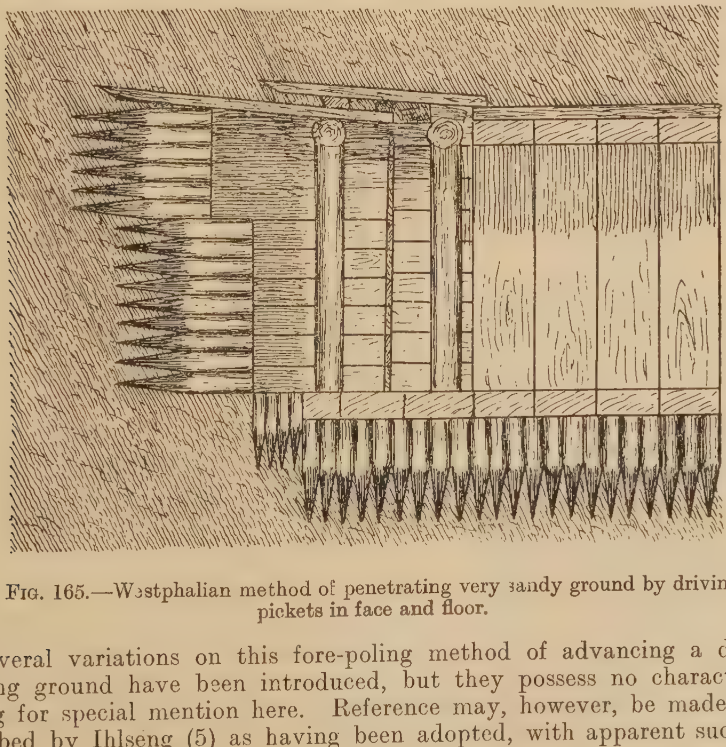


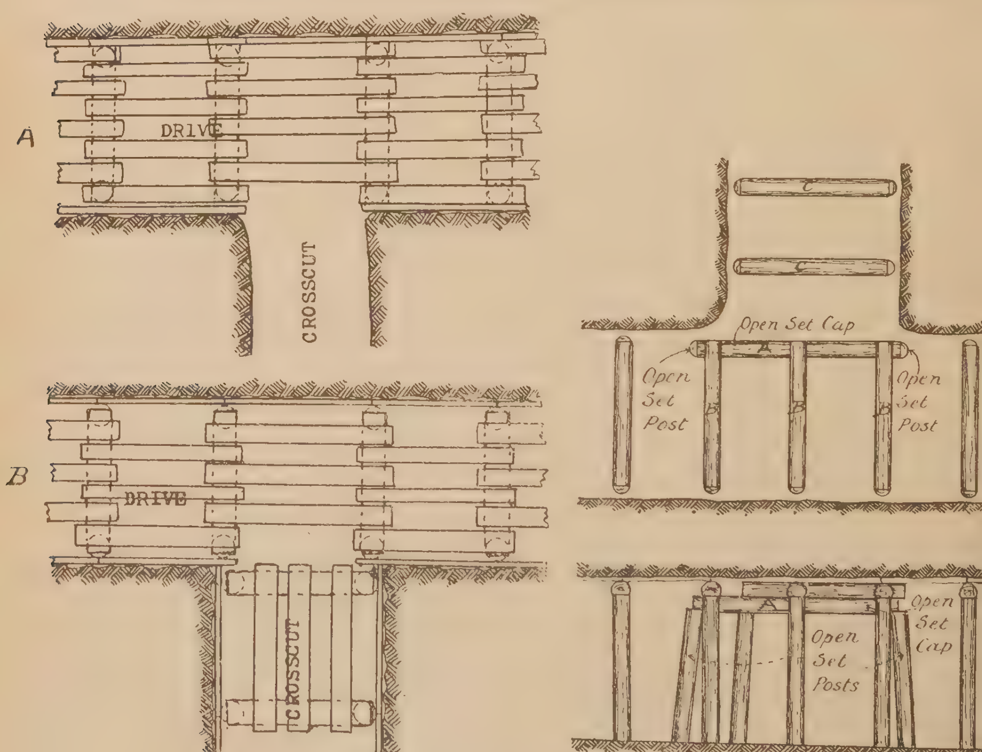
FIG. 165.—Westphalian method of penetrating very sandy ground by driving pickets in face and floor.

Several variations on this fore-poling method of advancing a drive in running ground have been introduced, but they possess no characteristics calling for special mention here. Reference may, however, be made to one described by Ihlseng (5) as having been adopted, with apparent success, in

Westphalia, Germany, in penetrating sandy ground, and which was unique in this regard, that in following it the sand was not removed but was forced ahead of the work. This method is shown in fig. 165 which, together with the following description, is taken from the *Manual of Mining*, by the author mentioned. "The walls and roof were fore-poled in the usual way, but the breast and floor were checkered by pyramidal pickets, completely covering the exposure. Those in the face were square-faced and larger than the floor-wedges, which were 12 inches long and 4 inches diameter, driven by mallets. The floor pickets remain in permanently, while those at the face force the soft material ahead and advance in this manner. The battering they receive renders them useless in a very short while, when they are replaced. There is no material to be hauled except that used in the construction, and rather bad ground has thus been traversed. On occasion a short lateral drift is similarly pushed to relieve the main work. Four men in a drift 5 feet by 6 feet in morainal matter will advance 4 feet a shift."

TIMBERING DRIVE JUNCTIONS.

The way in which the ground is supported at points in a level where diverging workings meet is determined at all times by the peculiar conditions existing.



FIGS. 166 and 167.—Timbering at junction of drive and crosscut.

In the case where a crosscut branches at a right angle from a drive, it frequently happens that the ground in the former will stand without timber

whereas that in the latter must be supported. Under such conditions, especially if the crosscut is to be narrow, it may be quite safe to open out as at A (fig. 166) without putting in any additional timber, but should the brow of the crosscut be weak, two sets may be placed under it, as shown at B, and poled over. If it is necessary that the crosscut be kept wide, the method of timbering shown in fig. 167 will usually meet all requirements. Opposite the mouth of the crosscut,

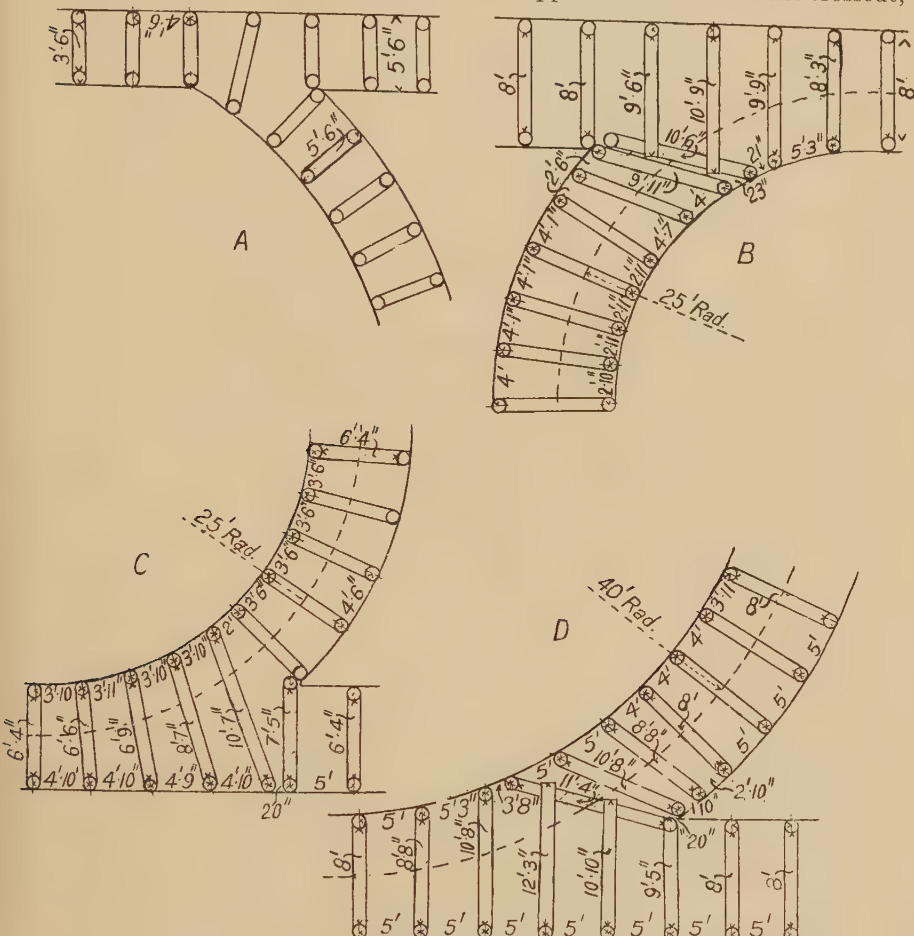


FIG. 168.—Timbering at junctions and curves.

and in the line of the ordinary sets, a wide set is stood, with the top of its cap A at the same height as the bottom of the caps BB of the drive-sets, which, in turn, rest on it. If the brow of the crosscut is heavy, one or two further sets CC are stood, and when these are lathed in the usual way the place will be secure.

At junctions formed at lesser angles, any of the various ways of arranging the timbers shown in fig. 168 may be employed, as necessity or convenience dictates. In standing his sets, the expert timberman will endeavour to have them as nearly as possible at a right angle to the ground, or, say, as at A or C, but as it is not in many cases practicable to do this, some such arrangement as shown at B or D must be adopted.

The methods so far described are those in which timber is wholly used. The employment of steel rails in conjunction with timber in supporting junctions is now becoming a fairly common practice, and in fig. 169 some idea is given of the manner in which they are used. There can be no doubt that in many mines

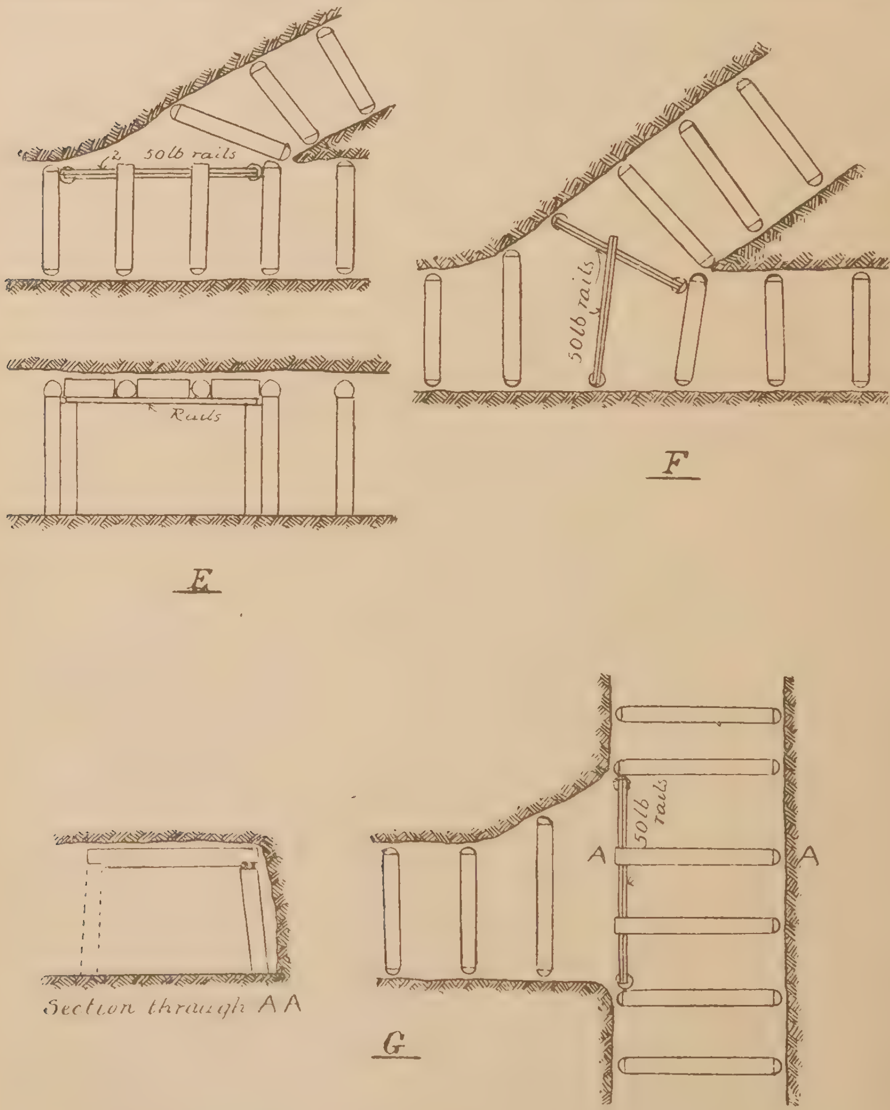


FIG. 169.—Timbering at junctions: use of steel rails as caps for sets.

the pressures exerted by the ground make it difficult to efficiently maintain such large openings when only timber supports are used. The main weakness lies in the long length of timber caps that is often necessary. By using old steel rails in place of long timber caps, the tendency of the whole timbering to be crushed is materially reduced, consequently the modern practice of using them in such positions is one that might well be more widely adopted than it is.

CHAPTER VII.

TIMBERING OVERHAND STOPES.

THE methods of recovering ore by stoping are very varied, but for purposes of classification they may all be described as coming under one or other of what are known to miners as the overhand and underhand systems.

The overhand system, as the name implies, covers those methods in which the winning of ore proceeds upwards from one level to another. In its various forms of flat-back, rill, or shrinkage stoping, it is the system in most general use.

The particular form of it adopted in any mine is determined by the width of the lode to be worked, the character of the enclosing walls, the nature of the ore, the class and quantity of timber available, and the cost of timber. In working a lode with strong walls needing little support, either the rill or the shrinkage methods would probably be most suitable, whereas if the walls are heavy and liable to flake on exposure the flat-back method would have to be followed. Again, even in working a lode by flat-back methods, it may be readily understood that in localities where timber is plentiful and of good class, a method of working may be admitted of that would be out of the question in a place where timber was scarce and costly, or of indifferent quality. Local conditions must always be largely the resolving factor in the selection of the plan of working that is to be followed.

TIMBERING A NARROW LODE WITH GOOD WALLS.

If the lode to be stoped is narrow, admitting, say, of a stoping width of up to 3 feet or 4 feet, and has a strong hanging-wall, the adoption of the stulling system throughout may be justified. Before the stulls forming the back of the drive are put in it is necessary to take off the leading stope partially

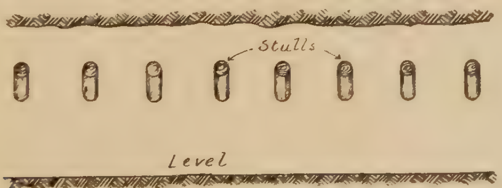


FIG. 170.—Timbering drive with stulls in narrow-lode.

if not wholly, as otherwise sufficient headroom would not be provided to allow of the timbers being put in place. This is sometimes done by taking the drive along at a suitable height, say 10 feet, as in fig. 170, but the practice most generally followed is first to take the drive in at the usual height of such workings, about 7 feet, then to come back and remove a leading stope, as in fig. 171, the drive stulls being put in one by one as room is made for them.

When the stoping is to be done on the flat-back plan, that is to say, in horizontal slices, the leading stope is beaten out to the full length of the shoot of ore, or, in any case, for a reasonable length along it. All of the ore from this first slice has, in the circumstances, to be shot down on to the floor of the drive, from which it is shovelled into the trucks. When the stulls forming the back

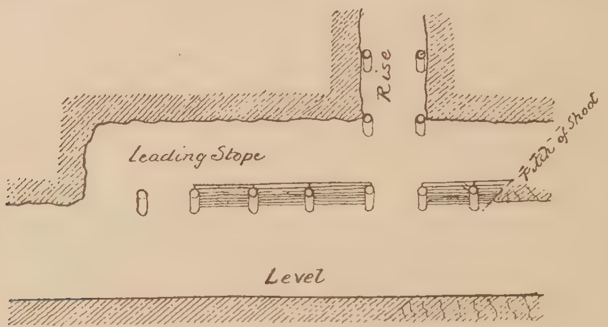


Fig. 171.—Timbering drive with stulls.

of the drive are in place they are decked over, usually with a double layer of laths or poles, openings being left at suitable intervals for ore-passes and man-ways, and the removal of a second slice is proceeded with. As a rise (raise) is invariably put up through the ore-shoot to the next level for ventilation purposes before stoping is started, the breaking of each slice of ore is usually begun from it. As the second slice is removed, another line of stulls is put

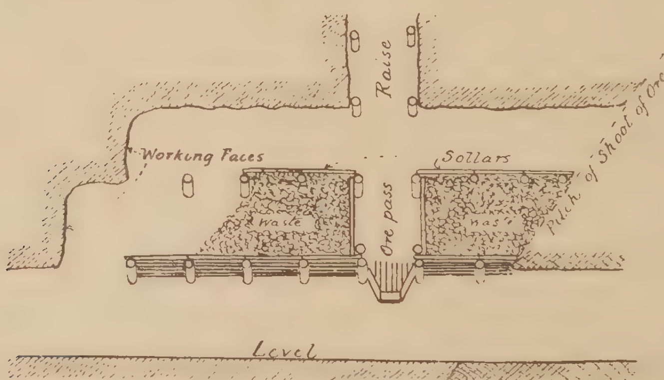


Fig. 172.—Stoping with stulls.

in in the usual way, any waste that may be broken with the pay-ore being stowed on the decking clear of the working faces. The stope then takes the appearance shown in fig. 172. If no waste to speak of is broken out in the ordinary process of shooting down the ore, and there is no special need to fill the depleted part of the stope, the work of mining the ore from level to level may be done by the workmen from stagings laid on the rows of stulls. This method is not at any time very satisfactory, and is now rarely followed. For one reason or another it is generally necessary to fill the worked-out part of the stope, and, as a rule, the filling is kept up well towards the backs.

If either the rill or shrinkage method of stoping is adopted (and either may be quite suitable even in narrow lodes if the walls are strong) much less timber will be required than would be called for in following the flat-back method. With shrinkage stoping it may not be necessary, indeed, to use any timber support in the stope, the broken ore itself filling the working from wall to wall, only sufficient being drawn off from time to time to give room for the miners to work comfortably. It is always a wise plan, however, even when mining on this method, to put in a stull wherever the hanging-wall shows any sign of weakness, as the likelihood of waste mixing with the broken ore is thus minimised, and, in the long run, a serious loss of pay-ore may be averted. The same remark applies to rill stoping. Only an occasional stull should be required, and no more should be put in than is necessary, as the presence of much cross-timber in the stope will interfere greatly with the rilling of the broken ore, the material banking up against it at times in such a way as to necessitate much loss of time in getting it to the passes.

Timbering Rill Stopes.—Rill stopes are invariably started from a central rise, as in fig. 173, the latter being needed not merely for efficient ventilation,

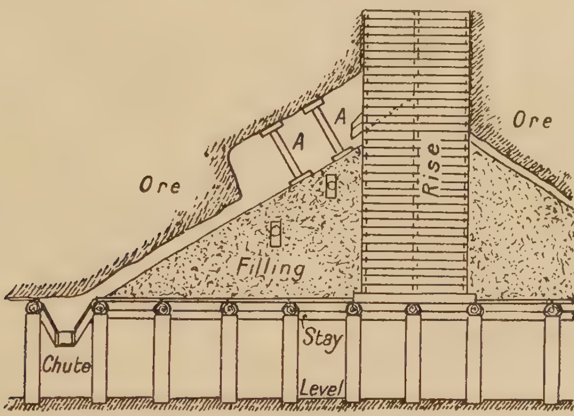


FIG. 173.—Opening out and timbering a small rill stope.

but also to enable the necessary filling to be run in conveniently. When starting a rill stope, a slice of ore is first taken off over the back of the level. Following this operation, the decking is placed on the drive timbers, and further ore is removed in such a way that the stope is about 15 feet high at the rise end, tapering down to the leading stope. The broken ore is then cleaned out, a temporary chute placed at a suitable height in the filling pass of the rise, and sufficient waste is sent down the latter to fill the stope up to within a short distance of the backs. Sollars are then laid on the filling, and a further slice of ore, this time of ordinary stoping height, taken off; the broken ore is again cleaned out, further waste run in, and so the work proceeds until the stope, at the rise end, is beaten up to within from 20 feet to 30 feet of the level above. During the course of the work, if the backs show any signs of weakness, props, with head-boards, are placed in as at AA, for the protection of the miners. In lieu of props, two-piece or three-piece sets may be used. These timbers are, however, only kept in place temporarily, and are usually removed when the next lot of filling is being run into the stope.

Flattening-off Rill Stopes.—As soon as the stope reaches in length the required distance from the filling pass, a permanent ore-pass is started, and

as the removal of the ore extends upwards this is carried up regularly, as at A (fig. 174). When the rill reaches within the required distance of the level above, the miners proceed to its lower point, and start flattening the backs off,

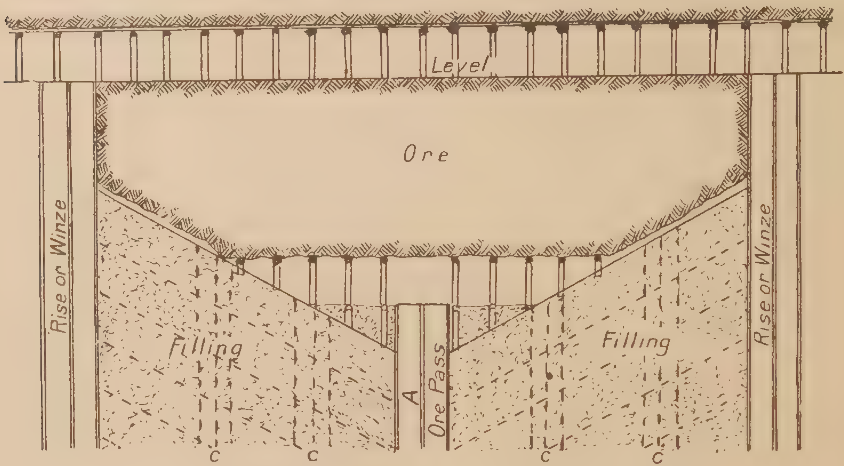


FIG. 174.—Flattening off stope after rill has been carried up.

as shown in fig. 174, and the remainder of the ore is taken off on the flat-back method. Sometimes intermediate ore-passes are carried up through the filling, as at CC, but their employment entails the use of much extra timber, and in a narrow stope they are seldom needed. In a wide stope, or in mines where the ore will not rill freely, it is at times an advantage to have them, but otherwise they serve no very useful purpose.

TIMBERING NARROW STOPES HAVING WEAK WALLS.

In stopes of this kind, the flat-back method of removing the ore has almost necessarily to be resorted to. Three- or four-piece sets are usually used to form the drive, these being erected in position when the level is first advanced. The next step is to take off the leading stope. This work may be started off a rise previously put up through the ore-shoot, or by rising for the stope at any suitable spot along the shoot, as shown in fig. 175. The ore broken in this stope rise must of necessity be shot down on to the floor of the drive, but the remainder of the ore taken off in the removal of the leading stope is usually kept up on the timber, from which it is dropped directly into trucks, thus saving a lot of unnecessary shovelling and at the same time allowing the routine work of the level being carried on uninterruptedly. This is effected by placing decking over the level timbers in the manner shown in fig. 175. Stout cleats *bb* are nailed across the level-sets near the bottom of the caps. On these, laths *cc* are laid lengthwise with the drive, but in the centre, directly over the trucking-road, a space is left between them about a foot in width, which in turn is covered by short pieces of timber, laid crosswise, as *dd*, thus forming what is known to miners as a *chow* or *chinaman*. If telescope drills are used for boring the ground the stope is drilled out by means of them with a series of holes put up directly from the level, as at *ee*, before the decking is put in place, but if hand-drilling is to be followed the ore is broken from the stope face itself by means of holes bored as at *ff*. When the ore has been

shot down, it is removed by withdrawing the short cross-boards as required, and allowing it to fall direct into a truck placed immediately beneath. As each set of leading stope is mined, these *chinamen* may be removed if desired

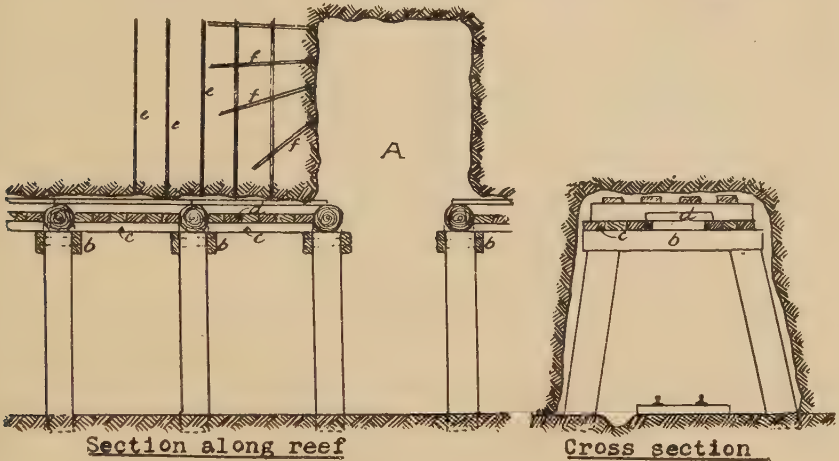


FIG. 175.—Taking off leading stope—use of *chinaman.*

and the permanent double-decking of laths placed over the caps of the level sets. As soon as room is made, sets of timber are stood in the stope, as at *aa* (fig. 176), and lathed or poled over the back and on the hanging-wall. Between these laths and the ground wedges are driven tightly, and to further

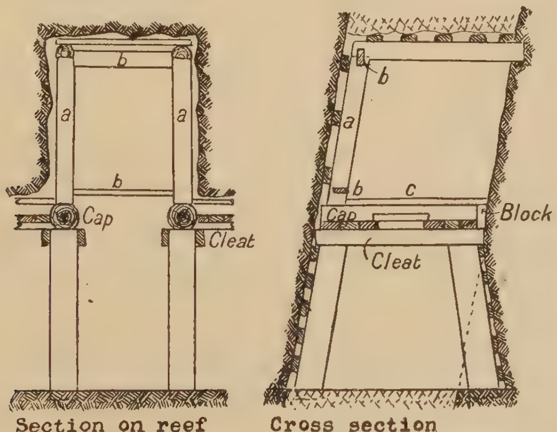


FIG. 176.—Showing construction of *chinaman.*

secure the timber from being shifted by blasting, the sets are well stayed one from another, as at *bb*. Drift-nailing is sufficient to hold the stays in position. In this order the timbering is continued throughout the entire stoping operation. As the stope extends upwards, the legs of each set rest on the caps of those immediately below, as shown in fig. 177, and to prevent the leg of the set being forced inwards, spreaders are spiked to the caps. In cases where the dip of the lode is very flat, the leg of the stoping-set is frequently stood as

at D (fig. 177), a wing-piece A being placed behind it to catch the wall. When the footwall is disposed to flake, a footwall leg B is used, its purpose being to prevent the cap of the set falling through its hitch carrying away. To effect the same purpose, a short prop C is sometimes put in instead of a leg.

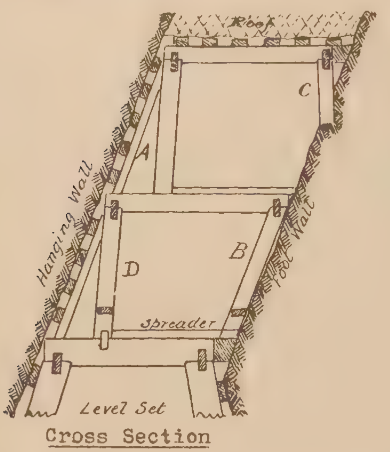


FIG. 177.—Timbering a narrow stope having heavy walls.

When placing the first stope-sets on top of the caps of the level-sets, it is advisable to place a stout chock of timber between the foot of the legs and the cap of the level-set, as in fig. 178, especially in ground where the latter are liable to be subjected to serious pressure. In the mines of the West Coast of New Zealand, where the three-piece set is invariably used in timbering levels, the sets are readily crushed down, necessitating replacement. When this crushing takes place, the stoping-sets usually come down more or less also, and when repair work is in hand, and the back of the drive is being raised to its normal height, the down-thrust end of the stoping leg gives a lot of trouble to the timbermen. By inserting a chock, as at A, much of this trouble is averted. Another plan that is followed to effect the same purpose is that of putting in a spreader, as at B, driving it down hard against the stoping leg, and then cutting off portion of the lower end of the latter. This must be done before a start is made to fill the stope. In the Blackwater Mine, Waiuta, West Coast, New Zealand, where a run of upward of 2000 feet of reef has been mined, the stoping is done throughout with the use of the method just described. In this mine the whole of the rock-drilling is done by means of telescope

FIG. 178.—Timbering leading stope in small lode.

machines, which bore the holes for blasting out each slice of ore from the stope below, as shown in fig. 179. It will be seen that in working in this way two stopes have to be kept open, and, further, that the quartz, when the shots are fired, is thrown back by the blast against the standing timber; nevertheless, so skilful are the miners in staying and securing the sets, a surprisingly small amount of damage is done. A very large quantity of timber is used, but as it is plentiful and comparatively cheap in the locality the successful working of the mine is not prejudicially affected. None of the timber is recovered.

In other mining regions, such as Western Australia, where timber is scarce

and costly, such a wholesale using up of it might easily mean financial disaster to a mine. Consequently in such places other methods of holding the stopes have had to be resorted to in order to minimise waste of timber. In the upper levels at least of the Ida H. Mine, Laverton, Western Australia, where the mining

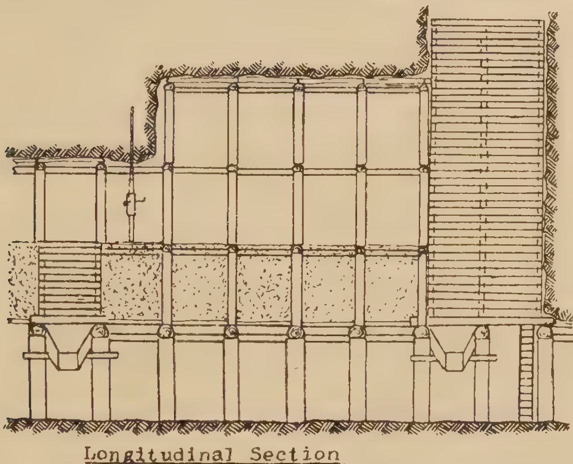


FIG. 179.—Method of timbering narrow stopes, Blackwater Mine, New Zealand.

conditions were as bad as in the New Zealand mine referred to, and all the stopes had to be closely timbered, a method of mining was followed that enabled nearly every piece of timber to be used again and again in different positions. In this mine, the hanging-wall was not exactly heavy, but was liable to fret away badly on exposure, and it was rarely that a full set of ground could

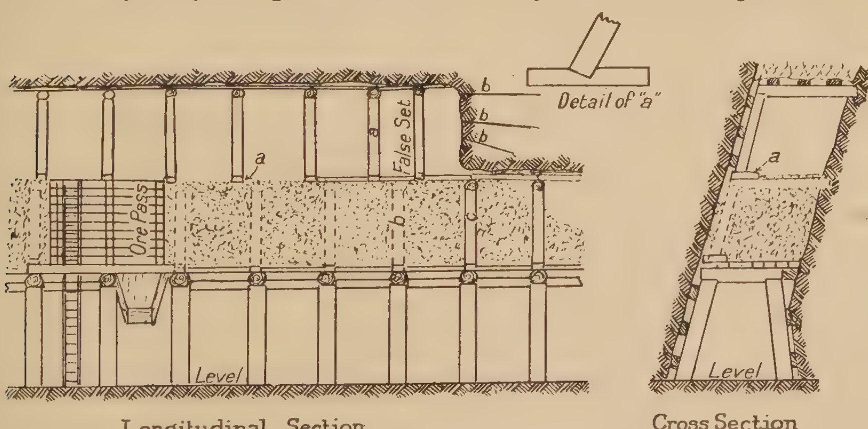


FIG. 180.—Timbering narrow stopes with a view to recovery of the timber.

be taken out in the stopes without a false-set being used. Timber of a suitable class was unprocurable locally, and a considerable portion of the requirements in this line had to be brought a long distance by rail and team. The flat-back system of stoping was followed, but to prevent waste of timber as much as possible, the stoping sets, with the exception of those of the leading stope, were not stood on the caps of the sets beneath them, but upon footboards placed on

the filling, as shown in fig. 180, and all the timber was put in without the use of nails, any necessary tightening being done with wedges. As each set in the stope below was passed over, the cap was removed from it, and the leg was drawn by means of a chain and lever. The only timber not recovered for further use consisted of a few side laths. To facilitate the drawing of the legs, they were stood with the smaller end down. This method of timbering compelled the adoption of a different method of breaking the ground to that followed in the New Zealand mine mentioned, the only stope kept open being that in which breaking of ore was actually in progress. Before the ore was shot down, the set beneath had to be filled, and all holes had to be drilled in a more or less horizontal position.

TIMBERING STOPES IN MEDIUM WIDTH LODES.

In timbering lodes of, say, from 15 feet to 20 feet in width, much the same methods as have already been described may be followed. In a general way it may be said that for lodes exceeding about 12 feet in width, the use of unsupported stulls is not advisable, but if good timber is available, and the lode-walls are strong, stulls of much greater length than this may be and have been used. They should, however, in all such cases be reinforced in some way. In a medium-width stope the extra support necessary may be afforded by placing collared *toms* under the stulls, as shown in fig. 181. Much mining has been done by the use of this single-stull method of supporting the walls, but it has its limitations, and should certainly never be attempted in mines where the hanging-wall is at all weak, unless filling of the depleted stope is intended.

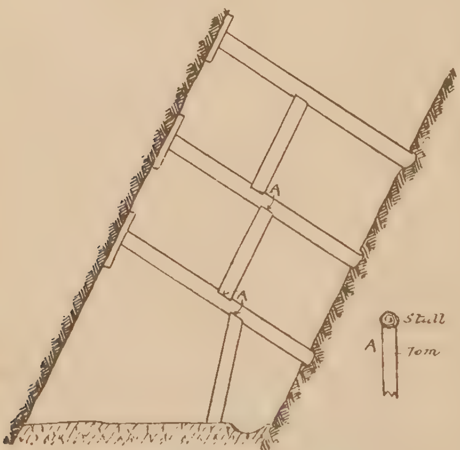


FIG. 181.—Stull-timbering in medium-width stopes.

Stoping with Batteries of Stulls.—By special arrangement of the stulls, it has been shown, nevertheless, that, provided the walls are good, lodes of much greater width can be safely worked. In the Lake Superior district of U.S.A., the adoption of what is known as the battery system of stull-timbering (see fig. 182) enabled stopes to be worked satisfactorily up to 40 feet wide. According to Rice (6), this method of timbering was adopted in the Calumet and Hecla Mine to replace a form of square-set timbering previously used. The stulls in this method are grouped in sets of three, the two lower of which are a little longer than the third. The batteries were put in at regular horizontal and vertical distances, caps being placed longitudinally over the shorter stulls on the hanging-wall end, with lagging, support being thus given to the whole area of the wall. Where the wall was so good that it did not require lagging, blocks were placed over the tops of the shorter stulls, which could be knocked out later and replaced by caps if desired. If round caps were used, they were flattened on the side on which they rested on the stulls. The stulls ranged from 16 inches to 30 inches in diameter, according to the width of the stope and

the condition of the hanging-wall, and were from 10 feet to 38 feet in length. The foot of the stulls forming the battery were stood directly on the footwall, but at the top, blocking was introduced so as to tie the group of timbers together when the battery took weight. The following description of the manner of setting the stulls is taken from an article by the authority mentioned: "These timbers are quite heavy, but they are easily swung into place by means of a rope from a small air-hoist placed out of harm's way at the foot of the stope, and passing up through a pulley secured to the top end of a heaving pole put in above where the battery is to be stood. The rope is fastened to the post (stull)

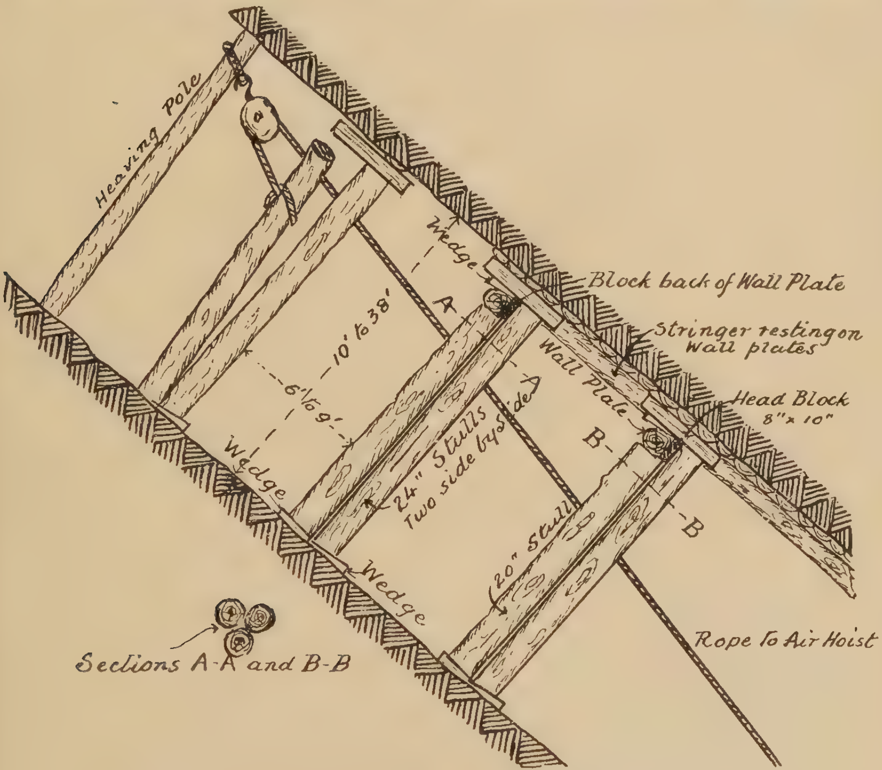


FIG. 182.—Battery-stull method of timbering in wide stopes.

of the battery up towards its top so that it can be lifted free of the ground and swung into place without any trouble. Then the rope is slackened somewhat, and the post allowed to swing down to where its head ought to come. One of the six timbermen in a gang then climbs up on a ladder and works in some top blocking to steady the post; then, resting against the rope that holds the post, he works in more blocking. The other one of the two bottom posts of the battery is then raised up into place and the process repeated, the top blocking being interlaced over the posts so as to tie them together. The front (shorter) leg is then swung up in place and allowed to rest against the other two. The wall-piece that extends from the next battery to this one is lifted up and blocked down from on top at both ends, this top blocking being interlaced with the top blocking of the posts of the battery. After the three posts have been blocked down from on top as well as they can be, and a sprag has been put in at the top

and the bottom to catch the two lower posts of the battery and brace them from the next lower battery, so that the upper battery will not be blasted out before the weight of the hanging-wall comes down on it, the last of the wedging of the posts into place is done from below where the men can get a better swing with their hammers. The wedges that are used are broad and about 18 inches wide. After the battery has been properly wedged, small stringers of round poles are put in running from cap-piece to cap-piece, and across this a grillage of top lacing is put in to catch the rock that scales from the hanging-wall."

A variation on the battery-stull system is shown in fig. 183. This method represents a combination of stull and set timbering, and is described by Storms (9) as having been adopted in the New Almaden Quicksilver Mine, California,

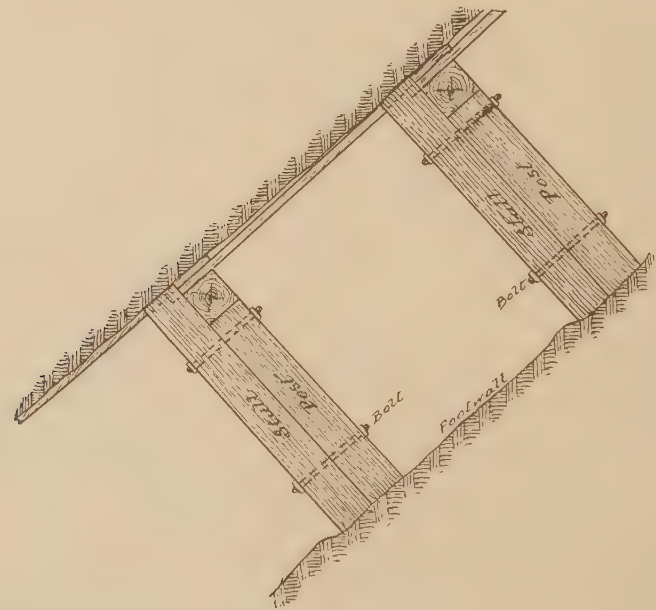


FIG. 183.—Combination of stulls and sets in stope-timbering.

U.S.A., for the support of soft and dangerous hanging-wall in stopes about 10 feet wide. Heavy stulls were placed in at regular distances of about 8 feet, and set in line one above the other. Immediately above the stull a second shorter timber was laid, which rested on the footwall and reached to within about a foot of the hanging-wall. A cap was placed over the top of this auxiliary stull, which reached horizontally across to the next pair of timbers which were similarly placed. Over the cap, lagging was put in, the top end of which rested on the cap and the lower end on the lagging of the next set above. The two stulls were then bolted together near the top and bottom for additional strength.

When a level is being opened out for stoping on the stull method, it is usual, whatever the width of the lode may be, to strip the ore from wall to wall on the level. The opening-out can be done as in fig. 184, a solid block of ore being left at one side, from which the line of stulls forming the drive is sprung, but this plan is now rarely followed. The same course can be adopted in opening out with set timbers, solid ore being left at one or both sides of the drive to

protect it, but the more common practice is to take out the ore to its full width. The drive is first excavated and timbered with three-piece or four-piece sets. On the West Coast of New Zealand, where the quartz reefs sometimes open out to considerable width, the custom is to timber as shown in fig. 185, with rows of king-posts and caps. The set that will subsequently form the drive or trucking-way is usually first stood, after which the lateral sets are erected as room is made for them. The caps are flattened on their lower sides where they rest on the posts. In the illustration, stays between the lines of sets have been left out for the sake of clearness, but they are always placed in in such a way as to protect both posts and caps from the effects of blasting.

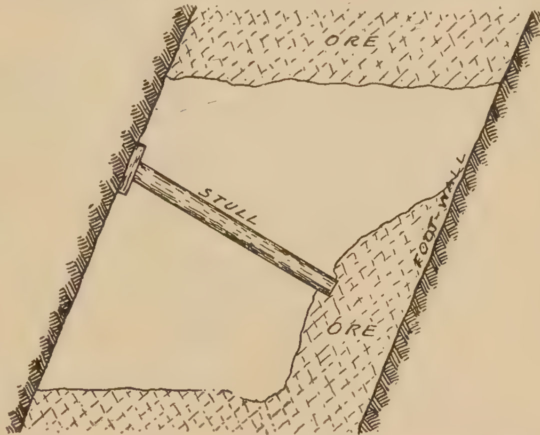


FIG. 184.—Opening out for stoping when stulls are used.

Once the timbering of what may be termed the sill floor is advanced sufficiently, a start is made at the actual stoping by taking off a leading stope one set wide, usually directly over the trucking-way, then opening out laterally in the same manner as previously to the limits of the ore-body, and erecting the timber line after line across the stope, and so the work goes on horizontally and vertically until the stope is beaten out. The lines of sets are generally spaced at 4-foot 6-inch centres. This method of timbering has been followed successfully in circumstances where the walls and the ore-body itself were very weak, needing close support, but the timber was not intended to carry all the weight, filling being run in as soon as possible.

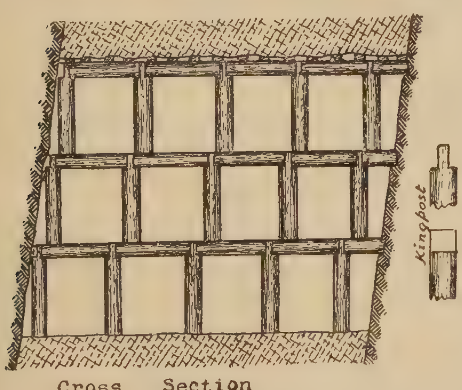


FIG. 185.—Timbering with king-posts and caps in wide lode.

One good point about this class of timbering was that it called for no great skill on the part of the workmen in preparing or erecting. The miners themselves stood the sets. Instead of using king-posts, a simple form of clap-me-down set, as shown in fig. 186, is occasionally used, and has been found to meet requirements very satisfactorily. There is a greater likelihood of the leg or cap being displaced by blasting than when king-posts are used, but

FIG. 186.—Clap-me-down stoping-set.

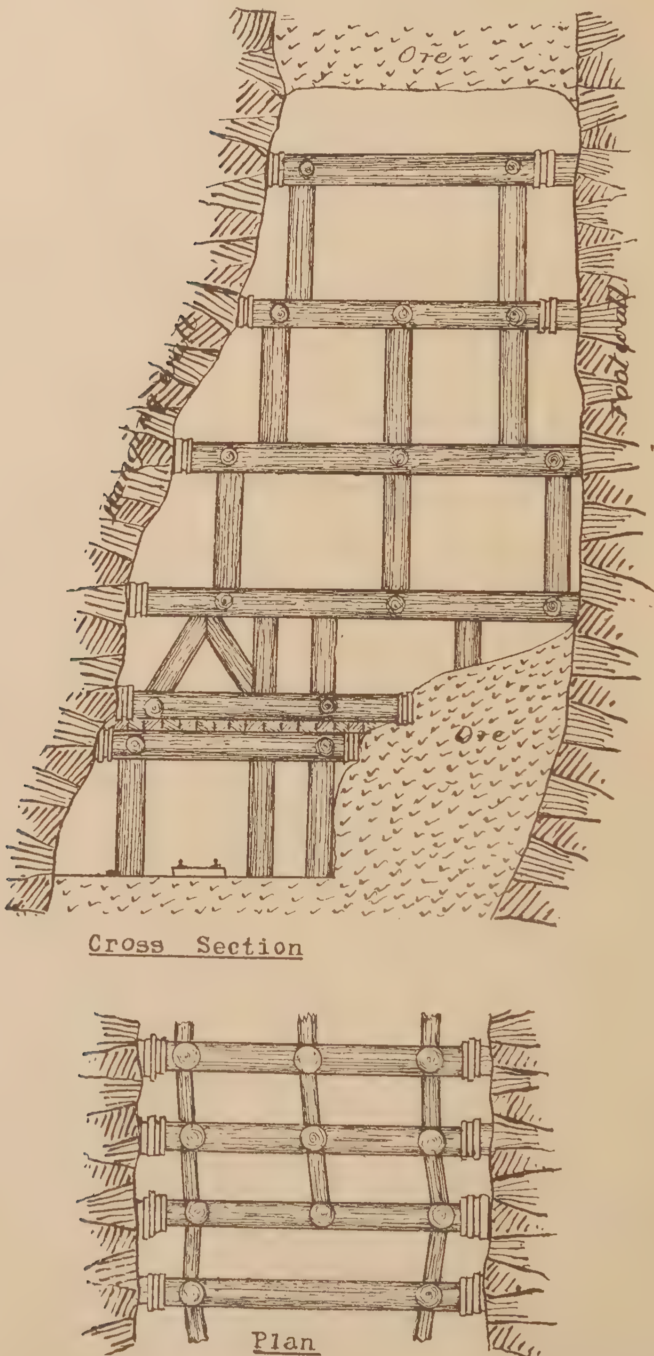


Fig. 187.—Cœur d'Alene method of combining stulls and sets in stoping.

if the staying is done properly danger from this source can be averted to a great degree.

Another method of timbering suitable for lodes of moderate width, especially in cases where the walls are heavy, is that shown in fig. 187, which is after an illustration published in the 1913 Report on the Mining Industry of Idaho, U.S.A. It was followed in the Morning Mine of the Cœur d'Alene, and represents still another combination of stull timbering and sets. In this mine the wall rocks had a marked tendency to swell, and thus exert tremendous pressure on the timbers. This pressure is said to have been so great at times as to broom up the ends of caps 20-inch to 24-inch diameter. The method is not used in lodes over 15 feet in width, but was commonly employed in the district in lodes up to that width. The timber used is from 20 inches to 24 inches in diameter, but even this is not sufficient to hold the walls, close filling of the stope being also necessary. Probably the most novel feature in connection with the method is that of using soft wood blocking between the ends of the caps and the walls, which could be removed as necessary to relieve the pressure. Caps and posts were stayed well one from another, and the latter were collared top and bottom to secure them further.

TIMBERING STOPES IN WIDE LODES.

Apart from the methods already described, many others have been, and still are, commonly followed in opening out a stoping base and securing the stopes in large lodes. Thus, in opening out on the lodes at Broken Hill, New South Wales, Australia, two drives or gangways might be put in, one on each wall, as was the practice in the North Blocks Mine, or a drive in the footwall country with a gangway in the centre of the ore-body, as was done in the North Broken Hill Mine. Again, for a main gangway, a timbered

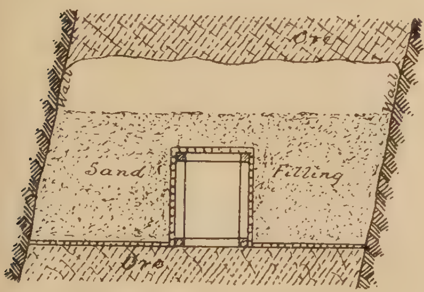


FIG. 188.—Timbering a main gangway in a wide lode.

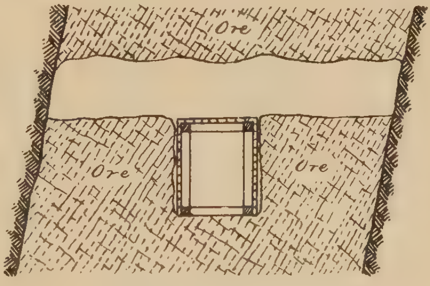


FIG. 189.—Timbering a main gangway in a wide lode.

way may be provided as in fig. 188, the ore being removed from either side and replaced with waste, or, as in fig. 189, with solid benches of ore left at the sides.

As far as double gangways are concerned, the practice of having one in footwall country is unquestionably founded on a wise principle, especially in working a lode in which creeps are liable to occur, for even if the gangway in the ore is crushed a safe approach to the workings is still available.

The leaving of solid ore on either side of the drive is also a good plan, for such a provision cannot fail materially to protect the timber, but the practice

of doing it is not in very general use. Fig. 190 shows how the method was employed at the old Fort Bourke Mine, Cobar, New South Wales, Australia. In that mine, the custom was to open out in such a way that the ore on either side tapered up to the walls. Until the ore had been stripped from wall to wall, the broken material was allowed to remain in the stope, only sufficient being drawn out at any time to give the men room to work, and temporary cribs being built up on it if thought necessary to support the backs. When the stoping had reached this stage all the broken ore was removed, and the bottom trimmed down across the stope, as at B, to the level of the caps of the drive-sets.

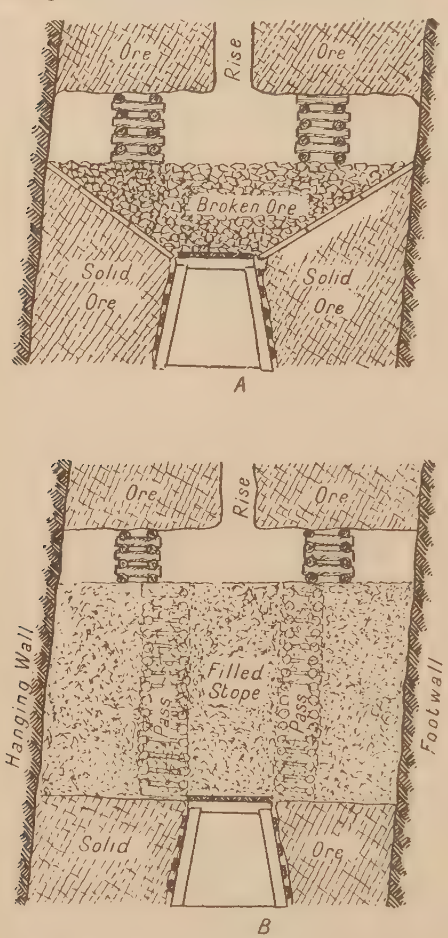


Fig. 190.—Stope-timbering—old Fort Bourke method, Cobar, N.S.W.

In cases when all the ore is removed from wall to wall on the sill floor, various methods of procedure are followed. If the ore is friable, the drive or gangway is first cut out to normal height and timbered, the side ore being removed set by set, but if it is strong the whole slice from wall to wall is taken out before any timber is stood. In the Broken Hill South Mine, according to Fairweather (20), the practice was first to take a slice 9 feet in height right across the lode, then to come back and take a second slice 7 feet in height, making an opening 16 feet from floor to backs. When the second slice had been advanced 30 feet to 40 feet, a start was made to stand the gangway timber, and this work was carried on steadily as the second slice advanced. About 1 foot of sand was next run in and spread on the floor of the opening on either side of the gangway, and on this 10-inch by 4-inch boards in 12-foot and 14-foot lengths were bedded close and level, with their joints broken. More filling was then run in on top of these boards, and as the stope advanced this filling was built up until by the time the second slice had been extended for its full length it had reached a height of 12 feet, or about 3 feet above the caps of the gangway sets.

In a similarly homogeneous ore-body in the Cobar Copper Mine, New South Wales, Australia, the method of stope timbering shown in fig. 191 was followed for years. When a drive had penetrated through the shoot it was intended to work, the ore was removed from wall to wall. A second slice was then taken off, giving the backs a height of about 15 feet from the bottom of the level.

When this slice had advanced about 40 feet, a start was made to form the gangway. This was done by laying down, on either side of the gangway, pairs of long, round-timber stringers, spaced about 5 feet apart. Across these, at intervals also of about 5 feet, shorter logs about 7 feet in length were placed, the timbers being slightly joggled to keep them in place. Then further pairs of long stringers were laid on, and these again crossed by the shorter logs, and so on till the required height was reached, when heavy logs were placed across side by side from crib to crib to form the gangway roof. At intervals bulkheads, built up in a similar manner, were erected on either side from gangway to the walls, and these were carried up to the backs. Between the cribs and the walls poles were laid down to form a floor, and on these filling was placed. The insides of the cribs were also filled with rough waste. This filling was carried up as the stope progressed, and kept always within working distance of the backs. Through it cribs of joggled logs were built up at the sides of the gangway, to serve as ore passes, manways, etc., and on top of it further temporary cribs were erected to support the backs whenever thought necessary. The Cobar lode was up to 40 feet in width, and was for a long period worked successfully in this way. Instead of using alternate layers of long and short timbers in forming the gangways and bulkheads, cribs about 7 feet square were sometimes used, and proved equally satisfactory.

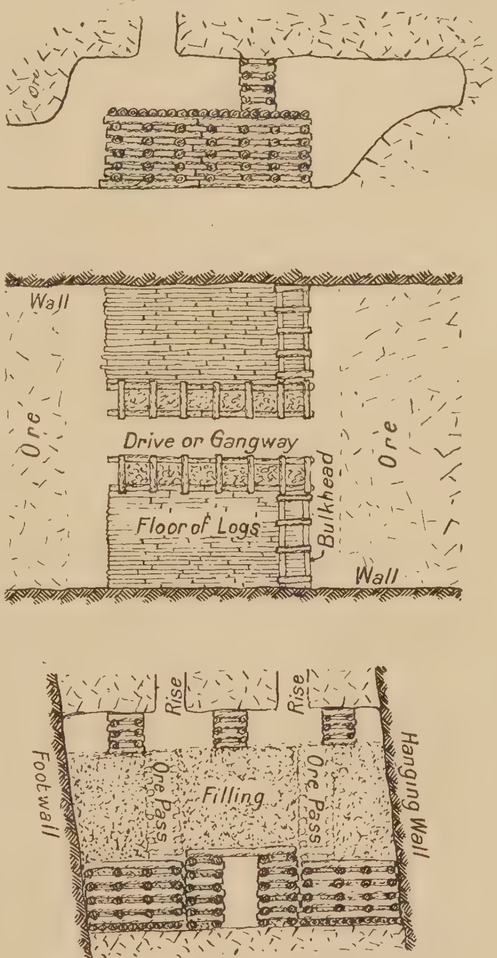


FIG. 191.—Stope- and drive-timbering—old Cobar method.

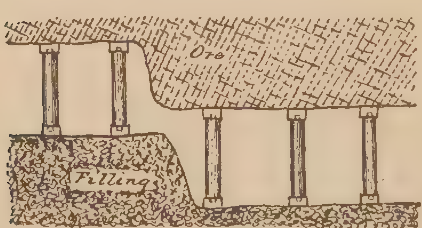
In the Fort Bourke Mine, Cobar, the level was formed of ordinary sets, the ore on either side being left intact. After the tapering benches had been trimmed down, as previously described, manways and ore-chutes of joggled, round timber were built up, and waste was run in from a central rise to within about 5 feet of the backs. On top of this filling, cribs or pig-styes of similar timber to support the backs were erected where thought necessary.

In the Prince of Wales Mine, at Adelong, New South Wales, Australia, where a wide lode was worked, a method differing slightly from the foregoing was adopted. The lode in this case had a fairly flat dip. A level was driven

and timbered with three-piece sets, after which the ore at the sides of the timber was stripped from wall to wall. At points along the line of lode, cribs of round timber were then reared to form bulkheads, and carried up to the

FIG. 192.—Stope-timbering, Adelong, N.S.W.

backs. Bottoms of long poles were laid in the usual way, and on these other cribs were started and carried up as shown in fig. 192. Filling was then run in to a suitable height, and on this additional cribs were built as required. These latter could be removed and re-erected as desired, but the permanent cribs were, as slice after slice of ore was mined, carried up to the backs as soon as room was made for them, and tightly wedged thereto. Ore-passes were carried up either on the footwall or hanging-wall. As the stoping progressed upwards, further permanent lines of cribs were started from the footwall and carried up to the backs, and so the work proceeded.



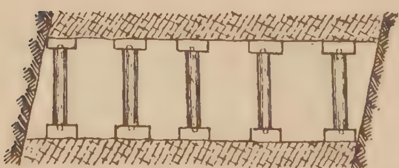


FIG. 193.—Stope-timbering—Lyell Tharsis Mine, Tasmania.

In other Australasian mining fields, in workings where the walls were fairly strong, still other methods of stope-timbering have been successfully followed. Thus, in the Lyell Tharsis Mine in Tasmania, where the lode was up to 50 feet in width, and the chief object was to steady the backs, Vale (23) mentions that the only timber found necessary, apart, of course, from level-sets, ore-passes, and manways, consisted of a series of props, as shown in fig. 193. These props were provided with head-boards and sills, and were of round timber. The head-boards and sills were of sawn or rough-dressed material. A mortice was cut in each, and tenons provided at the top and bottom of the prop to fit into them. The purpose of mortice and tenon was partly to strengthen the resistance of the prop to shocks resulting from blasting,

and partly to lessen any danger of it being sprung out of position by adjacent rock movements. These props were arranged in rows both across and along the stope, at suitable intervals, and as most of them could be recovered as the next stope was brought along, and were thus available for further use, there was very little waste of timber.

In the Sybil Mine, in the same district, much the same method was employed, the only difference being that instead of tenons and mortices being provided for props and sills, the former were cut square at the ends, fitting against a head-board, and resting on a split sill, such as shown in fig. 194, which, in order to give it greater stability, rested in turn on a bedding of slabs placed crosswise under it.

In the early days of the Broken Hill Mines, in New South Wales, some of them, working on the flat-back system of stoping, used the method of timbering shown in fig. 186, each row of clap-me-down sets resting on the caps of the row beneath it. The rows reached from wall to wall, and the stope was kept filled to within one set of the backs. Strong laths were placed transversely across the caps. For some time this method was followed generally on the field, with a good measure of success, but the passing of a number of the mines into the hands of American mine managers led to its replacement by the square-setting method of timbering. The latter did not prove the unqualified success it was expected to, serious fires resulting from the presence of so much timber in the stopes, causing much damage to the mines and offering much danger to the miners, and the old clap-me-down method was again resorted to, especially in the semifriable ore-bodies of which there were many in the mines. This time, however, according to Hebbard (48), as a new stope was brought along and mullocked up, the caps and back laths were removed and the legs drawn, no timber being left to lead fire from one part of the mine to another. In the long run the weight of the heavy flat-backs proved too great to be held in this manner, and it was also found that filling could not be done economically or efficiently, and the method was once more abandoned.

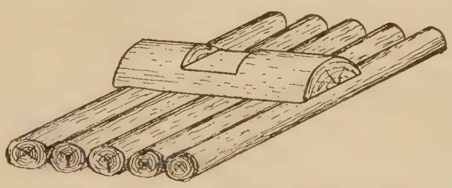


FIG. 194.—Foundation for props in stope-timbering—Sybil Mine, Tasmania.

In stopes on the same field where the backs were strong, the only timbering found necessary to effectually steady them consisted in erecting occasional cribs (locally, bulks) built up as shown in fig. 195. The ore on the sill floor was usually stripped from wall to wall, and to a height of about 15 feet. The sets forming the gangway were then stood, and filling was run in in sufficient quantity to cover them to a depth of about 3 feet. This filling was levelled off, and bulks built up on it to the backs, the number of them erected, and the spacing between them, being determined by the nature of the backs. In some cases the practice was to drive the level first to a height sufficient to give about 3 feet of space above the gangway timbers, and then come back and strip the ore on either side to the same height. As this side ore was removed, bulks were built up at suitable distances apart, just clear of the outside alignment of the gangway sets, and brought up to the backs, to which they were firmly blocked. Oregon timbers 10 inches by 10 inches in lengths of 6 feet were used for the bulks. Where the backs were at all friable, longer pieces of timber, as at AA (fig. 195), were placed across the bulks, and in turn lathed over. When the rows of bulks had advanced sufficiently, a start was made with the

erection of the gangway sets, and as these advanced the bulks were removed after the back had been caught up by other similar cribs built on top of the sets. The spaces on either side of the gangway were then mullocked up to above the height of the latter. The original height of the stope having been about 15 feet, there was now left a space of about 3 feet between the filling and the backs. In this space, and on top of the filling, further bulks were built up to hold the backs. A new stope was next started from one of the rises

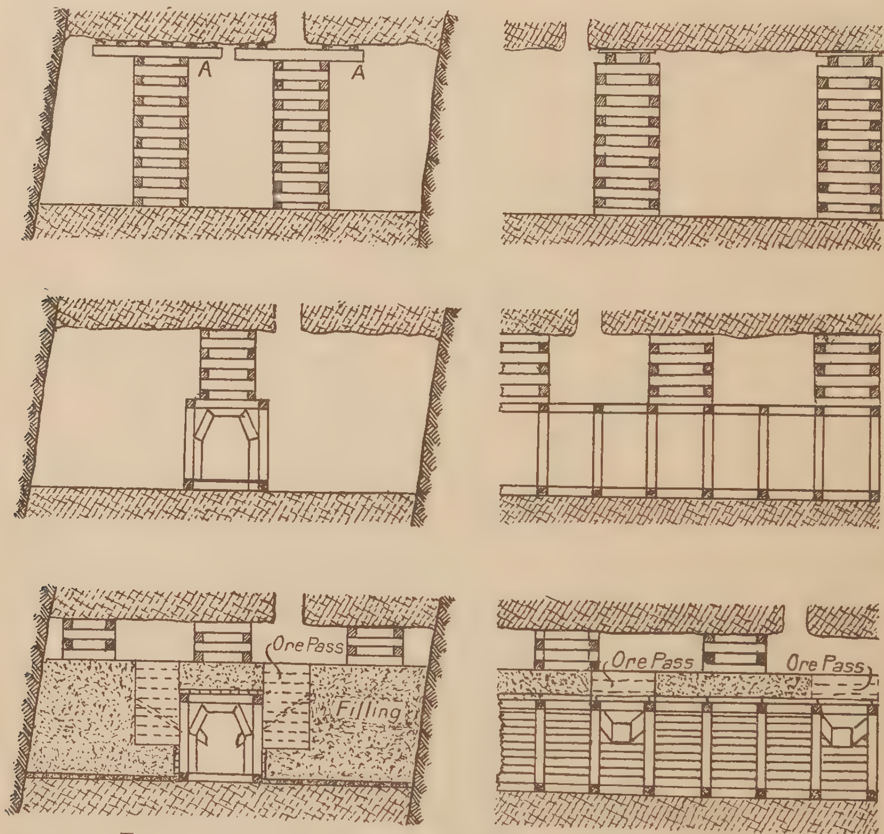


FIG. 195.—Open-stope timbering in wide lodes, Broken Hill, N.S.W.

previously put up through the ore-body for ventilating and filling purposes, and a slice of ore from 5 feet to 8 feet thick was taken off. When the ore thus broken had been removed, a space of from 8 feet to 11 feet was left between the filling and the backs. As the stope advanced, fresh bulks were erected in this space, the short temporary ones previously put up being removed for further use. When the stope had been carried a reasonable distance, waste was again run in, to a height of 6 feet to 7 feet, the various cribs being removed progressively and re-erected on the new filling. If care was taken, practically the whole of the timber could be recovered and used over and over again. Under weak patches of back, it was advisable at times to leave the timber. When erecting the bulks it was usual to first lay a sollar of 8-inch by 4-inch planks on the filling, in order that any pressure from the back might be

resisted by the whole area of the bulk. On this sollar the first crib-logs were laid transversely. The necessary passes for delivering the broken ore to the level below were brought up through the filling at suitable intervals.

This method of stope timbering is said by Hebbard (48) to have been first adopted in the British Mine at Broken Hill to replace the square-set system, and proved so successful that many of the other big mines on the field subsequently adopted it to a greater or less extent. Regarding it generally, the authority mentioned has pointed out that in employing it, whilst perhaps not very much had been gained in the way of saving timber, a very large stock having to be kept at hand or in use, and the cost of building the levels, ore-passes, and ladder-ways being much heavier than under the square-set system, the method had these advantages (1) that it provided a means of really securing the back and sides of a stope in hard ground, (2) that no connected run of timber was left through the filled-up stope to lead fire through the mine, (3) that ventilation in the stope was improved inasmuch as the whole of the air passing through was carried close to the working faces, and (4) that the space necessary for the economical working of the ground was obtainable without the risk of leaving an undue area of back unprotected by timber.

SQUARE-SET TIMBERING OF STOPES.

Apart from those already described, the only other method followed to any important extent in securing the stopes in wide lodes is that known as square-setting. Primarily it was intended by the originator of this method, Phillip Diedesheimer, who used it first in the Ophir Mine, Comstock, Nevada, U.S.A., that it should be in itself an absolutely sufficient support for the back and walls of even the largest lodes, and in some American fields very large ore-bodies have been worked solely by means of it in a safe and efficient way, the ore being taken from wall to wall, and level to level, without any filling being needed. In some places it has been found possible to do this with the simplest form of square-set, aided only by angle braces and wall-plates, but in most cases, even where the system has been very successfully used, considerable reinforcement has had to be given to the ordinary sets by diagonal braces, three- and four-piece liner sets, N frame-braces, N frame-sets, X frame-sets, bulks, spreaders, *toms*, and so on. In a general way it may be said that, no matter to what extent it is strengthened by reinforcing timbers only, the square-set has its limitations. In mines where the back weight or the pressure from the walls is not excessive, it may be used with good results, but there are many lodes in which its employment has not been a success. In Broken Hill, New South Wales, the system when first introduced there was enthusiastically taken up in the hope that by means of it the wide lodes would be effectively worked without the necessity of filling the stopes, but it was soon found that the timber by itself was totally inadequate to withstand the enormous pressures exerted against it. The mining men there also learned that it was a method of timbering quite unsuited to ground that had a tendency to run, owing mainly to the impossibility of driving laths at the corners of the sets. Creeps in the stopes were of frequent occurrence, some of them involving the displacement of many thousands of tons of material. Every expedient was resorted to by way of strengthening the sets without the desired result being obtained, and it eventually became necessary to fill all the depleted stopes. The square-set continued to be fairly generally employed in overhand stoping, but as fast as the ore was broken out, filling was run in. Strengthened in this way, the sets gave more satisfactory results, but even then the

mine managers of the field were not content with the position, and were constantly endeavouring to make improvements. The ultimate result was that

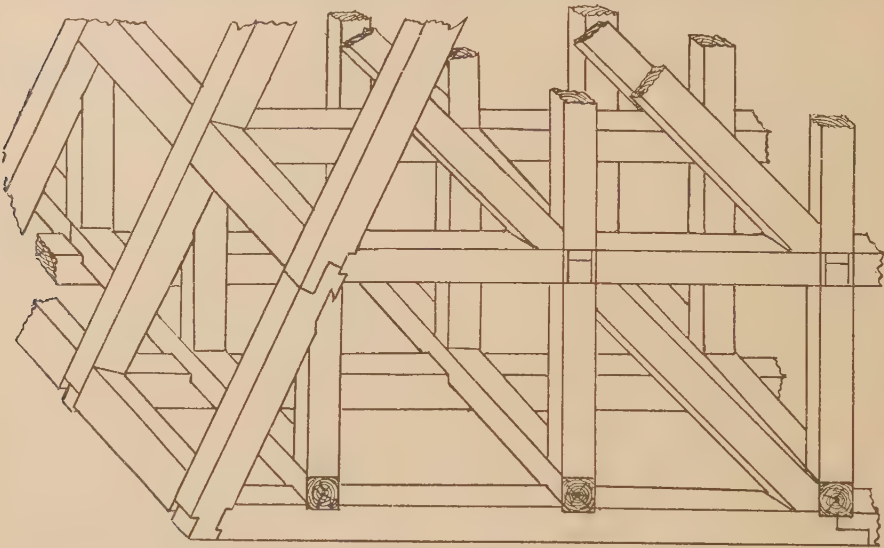


Fig. 196.—Square-set timbering—original Diedesheimer method.

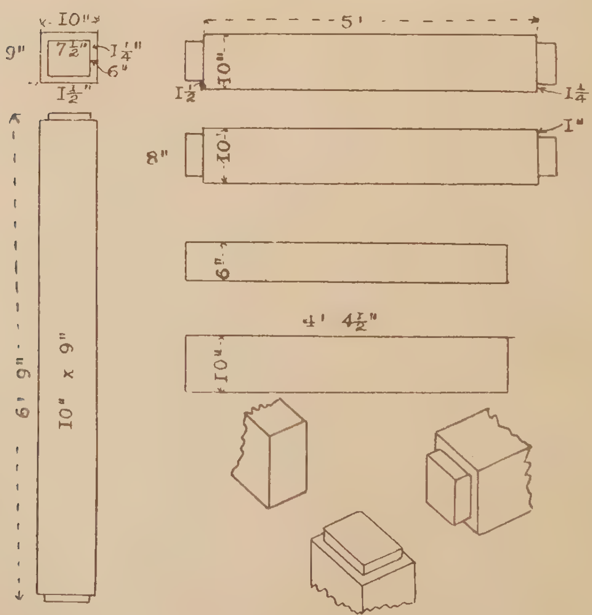


Fig. 197.—Square-set framing—Bingham method.

they practically discarded the square-set system in all except the very weakest stopes where overhand stoping was carried on, and then it was only used in conjunction with close-filling and bulkheading. The system has been retained,

however, in connection with a method of underhand stoping on the field which has now replaced the overhand method there in the removing of bridges, pillars, and bodies of crushed or very friable ores.

In attempting to give a description of detailed practice in square-setting, it must be made clear that there is no such thing as a standardised square-set. Fig. 196 will serve to illustrate the original method of framing and placing the sets as devised by Diedesheimer. The use of the wall-plates has now been generally discarded, and apart from that nearly all mining fields in which the system is used have their own method of framing the sets. In nearly all fields, too, the dimensions of the members of the set vary. On the Chillagoe Field in North Queensland, Australia, round timber is used, the posts are 6 feet overall (sill posts 7 feet), and the caps, which are all of similar length, are 6 feet 2 inches overall. In the Cœur d'Alene region of Idaho, U.S.A., the set most in use had legs or posts 7 feet 10 inches overall, made of 10-inch by 10-inch timber. The ties (also variously described as struts, braces, or girts) were 4 feet 8 inches of 10-inch by 8-inch timber, and the caps were of like dimensions. At Bingham, Utah, U.S.A., the posts of the set generally favoured were 6 feet 9 inches overall, of 10-inch by 9-inch timber, the cap 5 feet overall, of 10-inch by 10-inch material, and the tie 4 feet $4\frac{1}{2}$ inches, of 10-inch by 6-inch. In like manner, the framing of the sets differs in different localities. Figs. 197 to 201 will serve to show some of the many ways in which it is done. The first of these represents a manner of framing employed at Bingham, Utah, U.S.A. As the greater sectional area of the timber used in the caps, as compared with that of the timber in the

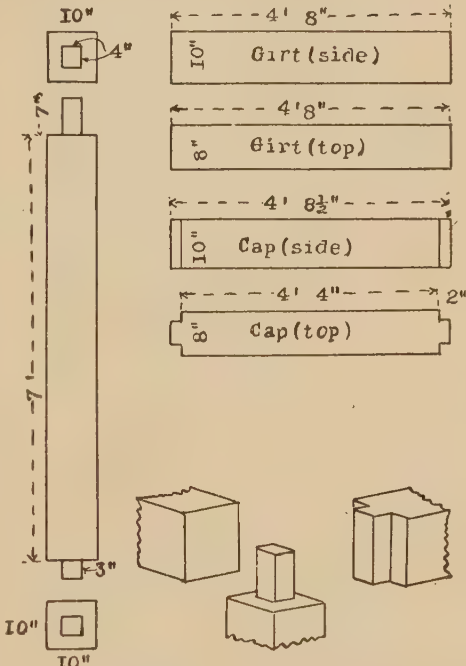


FIG. 198.—Square-set framing—Cœur d'Alene method.

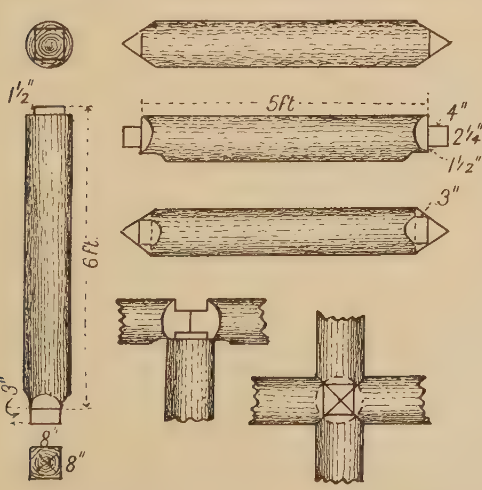


FIG. 199.—Square-set framing—round timber.

other members, will indicate, this framing was designed to give the set as much resistance as possible to side pressure, hence the size of the caps and the butting of their ends one against the other.

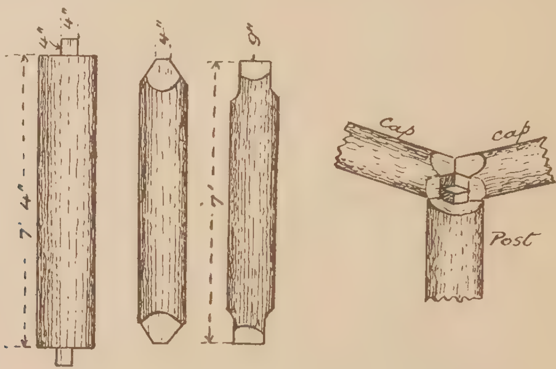


FIG. 200.—Square-set framing—round timber.

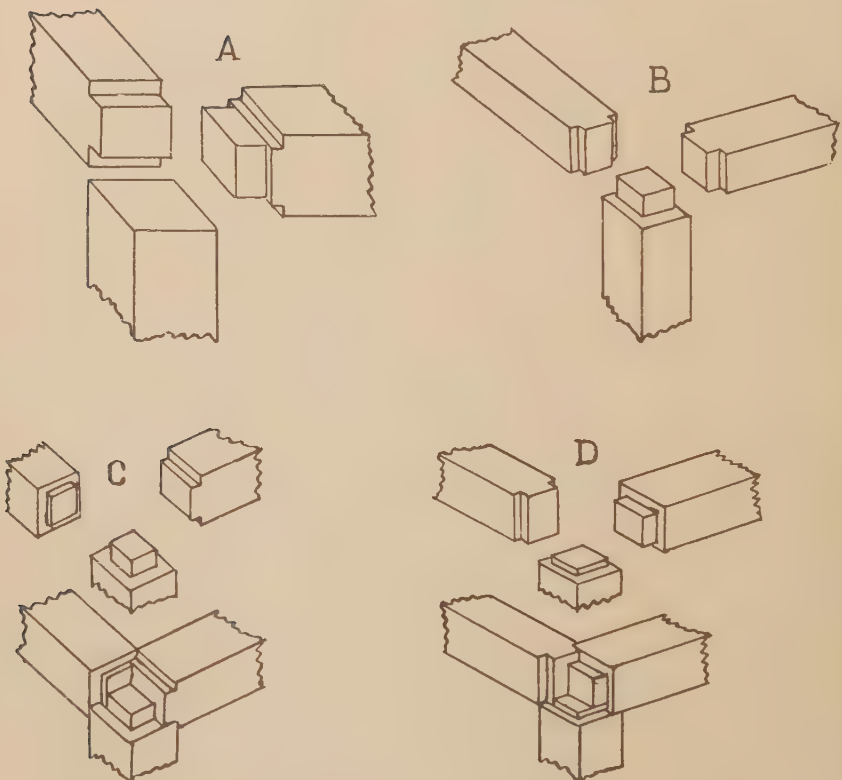


FIG. 201.—Various square-set framings.

Fig. 198 shows the framing of the Cœur d'Alene set. The moving principle in designing this set would seem to have been that of making the cuts as few as possible, thereby saving timber and strengthening the joints. Fig. 199 shows

the method of preparing the round timber sets used in such mines as the Girofla or the O.K., in North Queensland. Fig. 200 shows the framing employed at the Anaconda Mine in Montana, U.S.A., while fig. 201 shows a number of framings somewhat resembling the last mentioned in design, and all used to a greater or less extent in the same mining region. In the framings, those that have the caps butting one on another were designed to resist side pressures, while those in which the posts meet were meant to deal with vertical pressures.

A number of modifications of the square-set have also been adopted in various mining fields, one of which is shown in fig. 202. This was employed at the Utica Mine, at Angels, California, U.S.A., and other mines in the same locality. The sets were made of round timber from 24-inch to 30-inch diameter. The posts were 8 feet long, and provided with spills top and bottom, 14 inches square and 4 inches deep. The caps were framed also to 14 inches square at the ends, and horns 6 inches long were left on them. As the spill on the post was 14 inches, and the horns on the caps only 6 inches long, the ends of the adjoining caps were 2 inches apart when the latter were in place on the

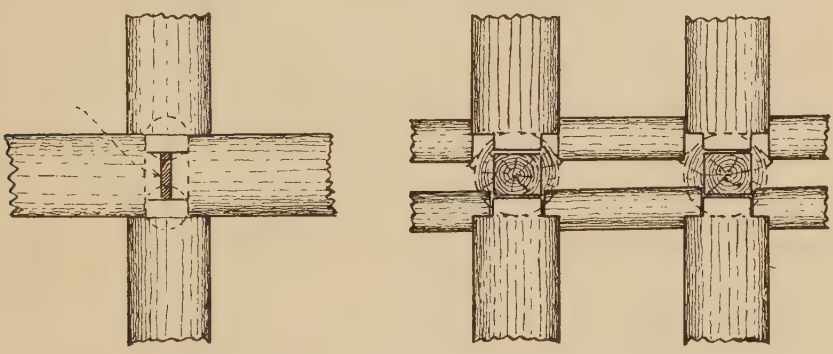


FIG. 202.—Modified square-set—Utica method, California.

post, but this space was filled by a piece of planking cut to size. In the place of the ordinary girt, two sprags or distance-pieces were used to hold the upper and lower posts in position. As will be seen, these sprags were set one above the other. The upper one was 4 feet in length, and was merely driven tightly down between the two adjacent posts, but the lower was 4 feet 8 inches overall, a horn 4 inches long being left on each end, which rested on the shoulders of the lower post. According to Storms (9) this system, while affording great strength when the timbers were properly placed, seemed to possess no advantages over the square-set, and to be more troublesome, cumbersome, and expensive than the latter, though the first cost of round timber was less than that of sawn square timber.

The same authority mentions that at the Wildman Mine, Amador County, California, a very similar method was used, the only difference being that the double sprags were arranged side by side to hold the caps, instead of one above the other to hold the posts, as in the Utica method.

Square-setting may be termed a method of supporting underground workings with an arrangement of open cubes or cells of timber, which key into one another and may be extended in any direction by the simple process of adding cube to cube. Fig. 196, which illustrated the system as first devised and used in America, will serve to give a good idea of the early method of framing and placing the timbers, while the cross-section of a stope shown in fig. 203

will serve to show the less elaborate but more generally adopted way of employing it nowadays, especially in Australian mining centres. In this fig. *aa* are mud-sills, *bb* posts, *cc* caps, *dd* blocking-pieces, *ee* stump posts, and *f* a diagonal brace. In Australia all the horizontal members of a set are termed caps, but in America it is the custom to discriminate between them, those running transversely to the stope being called caps, while the pieces placed longitudinally in the working are struts, ties, or girts.

Erecting Square-Sets on Sill Floor.—In opening out for stoping with square-sets the practice is, if the ore is friable, first to put a gangway through and

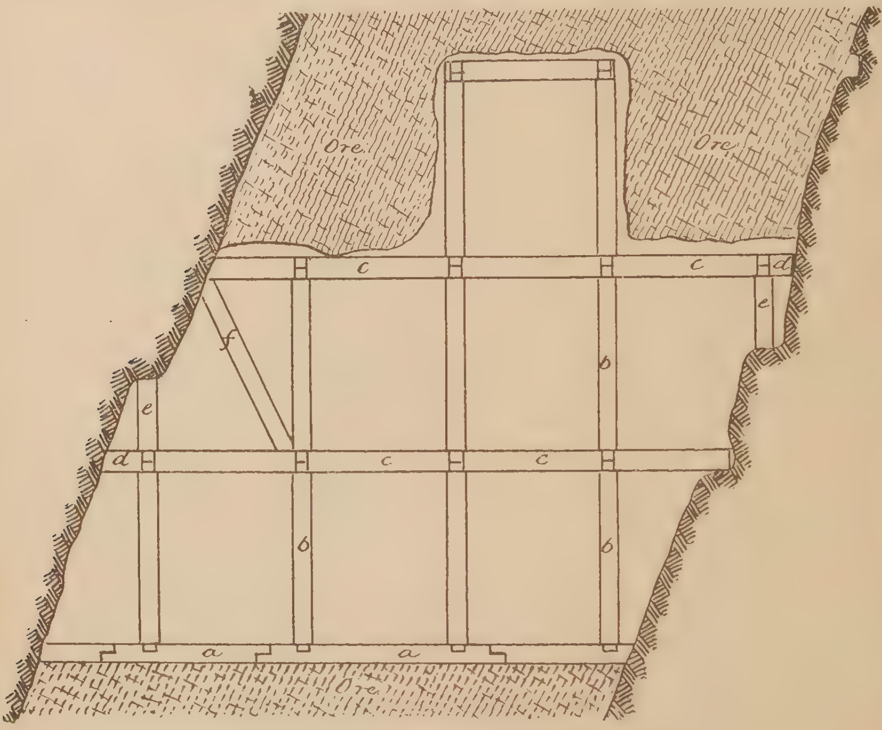


FIG. 203.—Showing general arrangement of square-sets in stope.

timber it, then to wing off the sides and extend the timbers laterally; but if the ground is reasonably strong, and the ore-body not of excessive width, it is the practice to take out a slice of ore from wall to wall to a height of about 15 feet. This first cut is known as the sill floor, and the timbers stood on it are termed the sill sets. These sets form the foundation on which all the other sets are built up, consequently the greatest care is taken to ensure that they are plumb, level, and in true alignment.

The writer has seen instances in which the posts of these sets have been merely stood on the rock-floor, but in the great majority of mines in which the system is used they are stood on a sill of some description.

This sill may be merely a length of 12-inch by 4-inch timber, laid longitudinally with the ore-body, as in fig. 148, but usually special timbers known as one-post or two-post sills, as shown in fig. 204, are employed.

Starting with what is intended to be the main gangway, which is generally

placed near the centre of the ore-body, two-post sills are laid at proper distances apart, transversely to the line of the gangway. In some mines these sills are given a slight dip in the direction of the entrance to the working, to admit of efficient drainage, but usually they are all put in on the one level, a spirit-level and straightedge being used to ensure accuracy in the work.

If round timbers, such as shown at A are used, it is not customary to frame them to carry a girt or distance-piece, but with sawn timber this provision is made, and the pieces are then put in as at *bb* (fig. 205). The posts are then stood in pairs, and the caps or ties placed on them, each post being plumbed and aligned carefully. The whole set is then wedged securely to the ground, if this be possible, but if wedging is out of the question battens are nailed on temporarily to tie the members of the set together and support them in position.

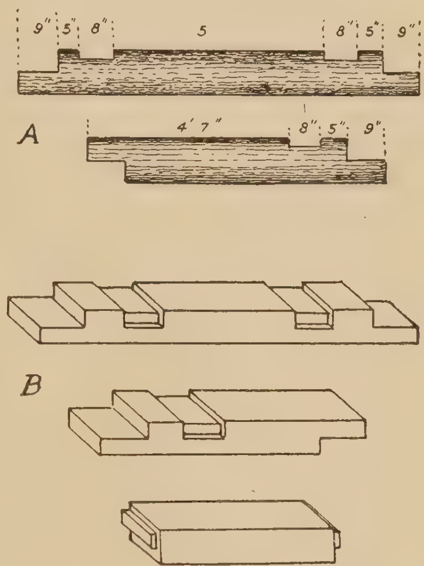


FIG. 204.—Mud-sills for square-sets.

When no housing is provided in the sill for the reception of the post, dowel pins which enter both post and sill are used to secure the former in place.

When the cap and girt are cut in the same way, and to the same length, as

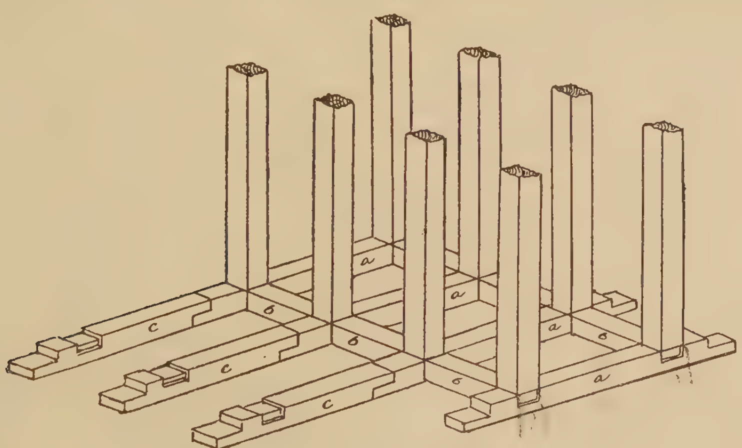


FIG. 205.—Method of placing mud-sills.

they are in the round-timber sets used in North Queensland mines, it is immaterial in which direction they are placed on, but if these members are of different lengths or sizes of timber, as in the Bingham set, the cap is placed in the line of the mud-sill, that is, across the lode. The gangway having been advanced some distance, a start is made to erect the lateral sets. In doing this, one-piece sills are bedded as at *cc* (fig. 205), with their ends overlapping

those of the two-piece sills. The first sets on each side of the gangway are then stood, and so the work goes on till the walls are reached, when all the lines of caps and girts are spragged to them with butt-caps, butt-sills, etc., and the whole structure as firmly blocked and wedged as possible.

It may be said that it is advisable at all times to use squared timber for the sills, as the latter can be more readily levelled than round timber and gives a better and firmer foundation for the sets. If round timber is used, distance-pieces of similar material may be dropped in between the sills if desired.

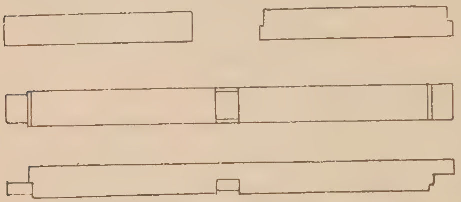


Fig. 206.—A further type of mud-sill.

In carrying on the timbering in an upward direction, much the same procedure is followed, the sets being stood with their posts directly above those of the sets beneath, and extended in the same way from wall to wall, all care being taken to keep the timbers plumb, level, and firmly wedged.

In place of the one- or two-posts sills, illustrated in figs. 204 and 205, the practice is followed in some mining districts, especially in America, of using what are known as long and short sills, the latter corresponding with what has previously been described as a tie or distance-piece. One method of preparing these is shown in fig. 206. In this case, the long sills have their ends halved, but frequently the halving plan is not followed, the sills being merely butted up against one another. The long sills carry three posts, and the manner of setting them differs from that followed when two-posts sills are used. Instead of being laid transversely to it they are placed parallel to the strike of the ore-body. In some mines using sills of this type, a start is made at erecting the sets by laying the first pairs of sills near the central line of the ore, but in others the practice is to start on the footwall side and lay the first line of sills close to it, ignoring any rolls in the wall, and taking a general parallel line with it, sprags or butt-sills being put in between the long sill and the wall wherever needed. In the same way, when the lines of sills approach the hanging-wall, similar sprags are put in and wedged tightly to close up all joints and bring the timbers firmly into their correct position.

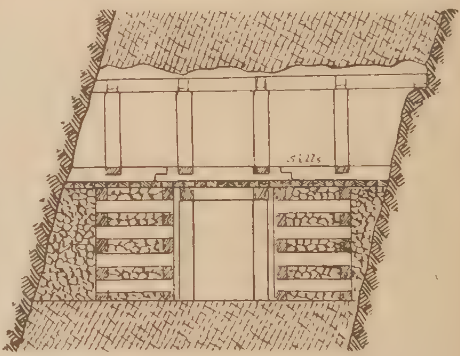


Fig. 207.—Starting square-sets over back of gangway.

Another variation on the arrangement of the sills is that shown in fig. 196, which illustrates Diedesheimer's original design. Here, short mud-sills, halved at the ends, are laid across the lode-channel, and on top of them girders sufficiently long to carry two sets are placed, the posts being stood on top of the latter.

One advantage claimed for the use of the long sill is that it makes the removal of bridges and pillars easier.

Still another variation on the ordinary setting of the sill floor is that shown in

fig. 207. In following this method, the gangway is timbered with three-piece or four-piece sets. Cribs of either round or squared timber are then erected on either side up to the height of the caps of the gangway sets, and filled closely with waste rock. Any space between the cribs and the walls is also filled. A heavy timber floor is then laid over the entire stope, except those parts where manways and ore-passes are to be brought up, and on top of this flooring the ordinary sills are laid, and the stoping sets stood in the usual way. The object in timbering in this manner is, obviously, the securing of the gangway. The filling in a large stope naturally exerts tremendous pressure on the gangway timbers, and it is possible that cribbing built up as shown would strengthen them materially to withstand it.

Wherever the square-set system is employed, it is almost the invariable rule to use somewhat longer posts in timbering the sill floor than are used in the stoping sets proper. The object in doing this is to provide adequate headroom in the gangways for the handling of long timbers, ladders, rails, etc., for the convenient arrangement of chute-doors, and for allowing air and water-mains, electric light and power cables to be carried along well out of the way of the workmen. The posts on this floor are thus seldom less than 7 feet in length and are usually a little longer than this. In standing the first lines of sets, great precision is necessary, and the surveyor should be in attendance to ensure that at least the first three or four sets are stood in proper alignment. Once these are placed, the timbermen can be trusted to carry on the work. A slight mark is made exactly in the centre of the underside of the gangway caps, either by making a line with chalk or by driving in a small bright-headed tack (sawcuts should not be permitted). As each succeeding set is then stood, lines are hung from these marks, and the posts are stood so that these lines correspond. Once alignment is reached, the posts are stayed up firmly by nailing diagonal planks to them and tying them together temporarily with braces of 10-inch by 2-inch timber. The greatest care is necessary to see that all joints are properly closed up. At suitable intervals sets are marked off as ladder-ways and chutes on either side of the gangway. As a general rule, ore-chutes are spaced about 30 feet from one another, and ladder-ways about 100 feet.

Once the sill-floor timbers have been all stood, if it is intended to run in filling, in accordance with modern practice, a floor of planks at least 4 inches thick is laid on the sills from wall to wall, its purpose being to enable the ore immediately beneath the level to be subsequently recovered. The gangways and the offsets for manways, ladder-ways, etc., are also lined on their outer sides with similar material.

In opening out for each succeeding floor of sets above the sill floor, it is usual to make a start from a rise, all holes being bored in a downward, or a horizontal position, wherever possible, and each set is stood as soon as room is made for it.

It is not necessary to timber the whole of any one floor or stope before starting on the next succeeding one, but the timber on the lower floor should be well advanced before the opening of another is attempted. In wide stopes it is advisable not to work more than one floor at a time, for the simple reasons that in working a stope in steps more timber is required for *paddocking* or *coralling*, and there is always the danger of the sets in the lower open stopes being jackknifed, that is, screwed out of square. In any case, too much stress cannot be laid on the necessity for tightening every set in position as rigidly as possible by wedging and blocking. If the backs are high above the set, planks should be placed across the caps, and cribs built up to the ground.

As the sets approach the walls of a stope it is neither customary nor necessary, save where the wall is flaky, to always make room for a full set. Fig. 208 shows a variety of ways in which the sets are closed to the walls. On the footwall a butt-cap is usually put in, as at *k*, and wedged tightly. This butt-cap is framed like the ordinary cap at the end resting on the post, but is cut off square at the other end. If desired, the butt can be hitched into the wall. In cases where the wall is flat, stump-legs may be used, as at *i*, or cap-sills may be put in, as at *j*. In the same way butt-caps may be used on the hanging-wall, as at *k*, but when this is done it is as well to support them by a diagonal *l*. In other portions of the figure some of the many ways of reinforcing the sets are shown. A piece of timber put in as at A is called a spreader, B and C represent three-piece and four-piece liner-sets respectively, D is an angle-brace, E an X-brace, F an N-frame-set, and H a *tom*.

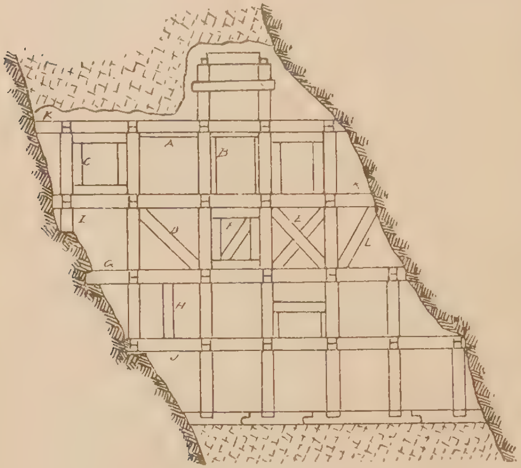


FIG. 208.—Showing methods of reinforcing square-sets.

Preparing Square-Sets.—In mines where large quantities of timber are

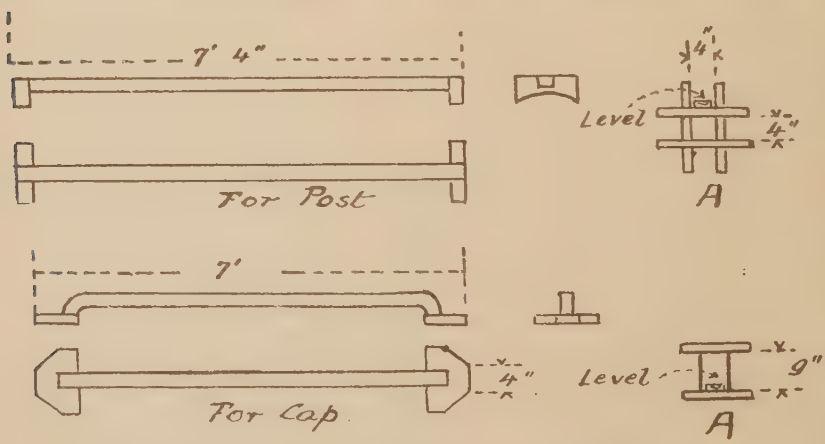


FIG. 209.—Template for framing square-sets of round timber.

used the sets are prepared by means of specially designed framing machines, which do the work expeditiously and accurately. The machine has to be constructed to suit the particular framing in use. When the cutting is done by hand, templates or mitre-boxes are employed. The most difficult sets to prepare are those made from round timber.

In framing the set shown in fig. 200, templates such as illustrated in fig. 209 are commonly used to mark off the cuts. The piece of timber from which

the post or cap is to be made is laid on a pair of bearers bedded in the ground, and is secured against movement by being wedged from uprights—usually round iron bars—on either side, or else by means of short iron dogs, as at B (fig. 210). The template is then laid on top of the timber, and kept in place by two small spikes passing through holes previously prepared in it, and driven into the log. To set off the spills on the ends, the cross-cleats AA are used. It will be noted that on the cleats a small spirit-level is mounted.

Slightly different templates are needed for cutting the set shown in fig. 199, but an experienced timberman can prepare sets to suit any particular framing without difficulty.

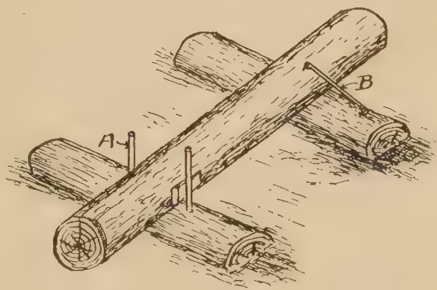


Fig. 210.—Cutting square-set from round timber.

Instead of using templates, many timbermen mark off all the cuts merely by use of a level and straightedge, and at times by means of a straightedge only, sights being taken from one end of the post or cap to the other to keep the faces of the spills in the same plane. Owing to the irregularities in size and shape of round timber, it is rarely that the sets can be cut to join together as well as could be desired, if the preparation is done in any of these ways. By using a mitre-box much more accurate framing can be ensured, and for this

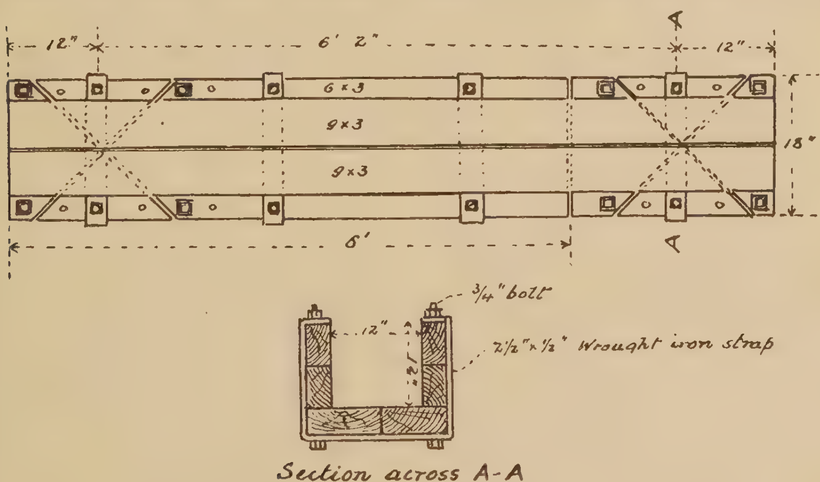


Fig. 211.—Mitre-box used in cutting square-set timbers.

reason it is always advisable to use one, a great deal of the value of the set underground being lost if the timbers do not joint closely one with another. Fig. 211 represents a box used in framing sets such as shown in fig. 199.

TRIANGULAR STOPING SETS.

The method of securing stopes by a triangular arrangement of set-timbers has not been adopted to any important extent, although from theoretical and economical points of view it would seem to offer advantages over the

square-setting system. About 10 per cent. less timber is required, and as any stresses that may be exerted against sets of this kind are distributed between more of the members than would be the case with the square-set,

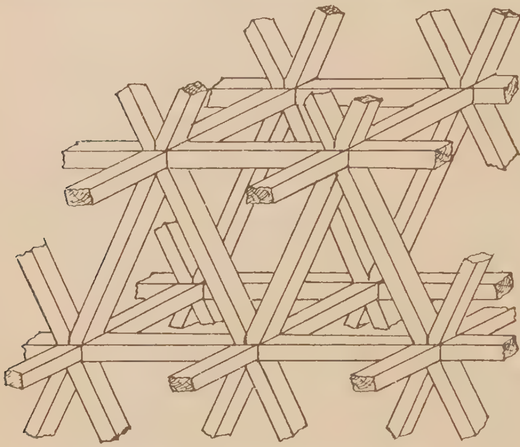


FIG. 212.—Triangular stoping sets.

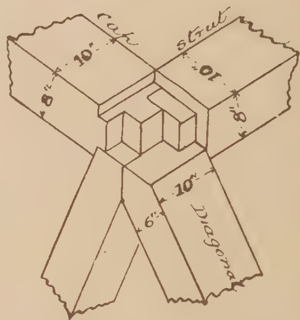


FIG. 213.—Details of joint, triangular stoping sets.

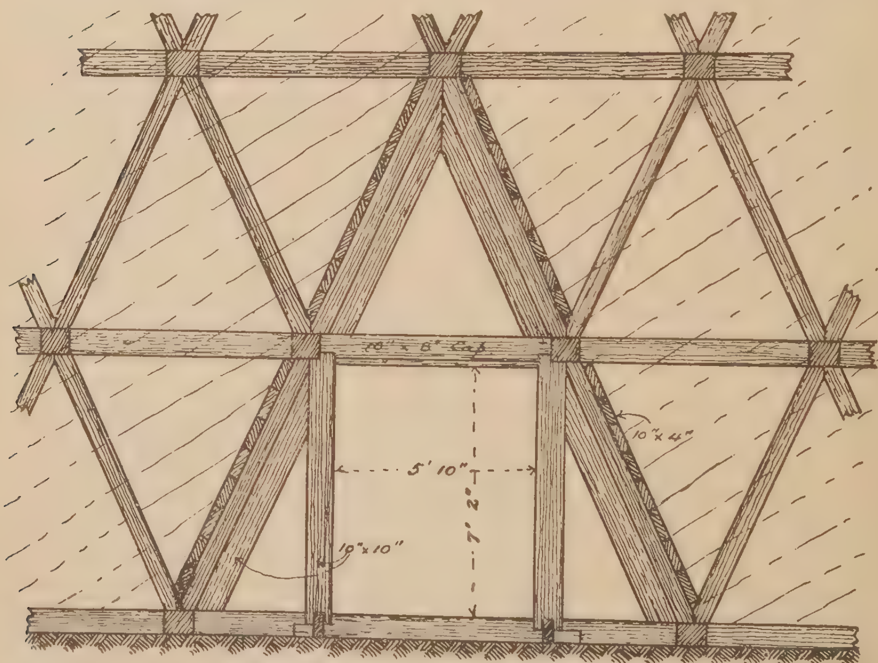


FIG. 214.—Construction of gangway in triangular stoping sets.

their resistance to pressure should be greater. Partly with a view to saving timber, and partly in the hope that greater strength would be secured, the system was introduced in an American mine, the Tenopah-Belmont, Tenopah, Nevada. Fig. 212 will serve to give a general idea of the arrangement of the

timbers, while fig. 213 shows the details of the framing. In the mine referred to, the use of this method appears to have given satisfactory results, but it is not a class of stope support that will appeal to the great body of mining men. One of the most serious drawbacks it presents is the difficulty of efficiently securing and wedging the individual set. The method of arranging the gangway timbers when using sets of this kind is shown in fig. 214, which, with the two previous illustrations, is taken from a description of the method by Moore (53) appearing in the *Transactions of the Australasian Institute of Mining Engineers*, 1912. In his paper the writer also described various modifications of the system for use in rill stopes and in underhand stoping, but as they are merely suggestions, and have not, to the present writer's knowledge, been put into practical use anywhere, they need not be detailed here.

CHAPTER VIII.

TIMBERING UNDERHAND STOPES.

What is known as underhand stoping is the removal of ore by working downward from one level to another instead of upward as in all other systems. It is not by any means widely followed, but for certain kinds of ground is to be preferred to the overhand method. In the Australian Broken Hill Mines it is now almost exclusively used in working out bridges left under old levels, pillars of ore that have been badly crushed, or portions of lodes that are naturally of friable nature. It is also employed in recovering ore from sections of the mines that have been on fire, and in which the roasted material has been reduced to a floury condition. For the working of such bodies, the mine

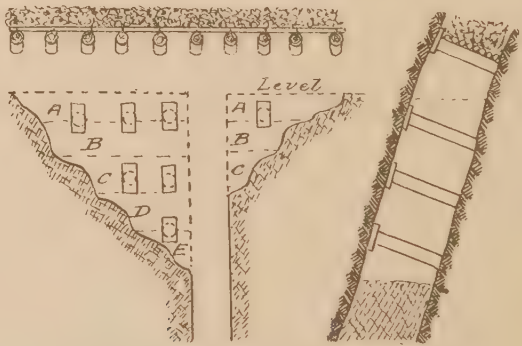


Fig. 215.—Underhand stoping with stulls.

managers of the field have, after much experimenting, satisfied themselves the underhand method of operating is at once the safest and most economical.

Apart from this Broken Hill square-setting method, the only others employed in underhand work are of the simplest description. The one that has been most generally resorted to is shown in fig. 215, and consists merely in putting in a stull, with head-board, here and there where most needed. Where the method was followed, the procedure was to connect two levels, driven along the course of the lode, by rises or winzes, then to start at the top of the latter and take off a slice of ore, as at A. When this slice had been cut for a certain distance, a second slice B was broken out, following which slices C, D, and E were taken in succession, until the general appearance of the working was that of a rill, all of the broken ore gravitating to the rise (or winze) which served as an ore-chute. As the work progressed, this rill was preserved, and the miners from time to time, as occasion demanded, put in a stull in the same way that such timbers would be placed in a drive. These stulls were not necessarily placed in regular rows, or at regular intervals, but only where the hanging-

wall showed signs of weakness. It was a cheap method of stoping, but had serious disadvantages, not the least of which was that its adoption meant that the level above the stope was lost for all practical purposes.

A variation, such as shown in fig. 216, on this method was followed to a considerable extent by old-time miners. This consisted in putting in horizontal rows of stulls which were slabbed over for the purpose of providing

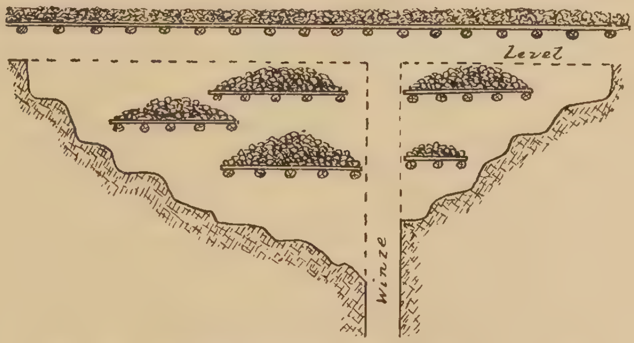


FIG. 216.—Underhand stoping, with sollars to hold waste.

places on which waste could be stowed. This plan afforded an opportunity to hold back a good deal of valueless rock which would otherwise have found its way into the ore-pass, and at the same time gave a certain amount of protection to the miners. Throughout the mining world such methods are now generally looked upon as altogether too primitive to suit modern conditions, but they satisfied the miner of earlier days, who was not too well looked after by the mining laws, and was himself inclined to run undue risk in carrying out his work.

UNDERHAND STOPING WITH SQUARE-SETS.

At Broken Hill, prior to the adoption of the underhand method for the working of friable ores, many other systems were tried, among which were flat-back stoping with rows of clap-me-down sets, overhand stoping with simple square-sets, stoping with square-sets reinforced by filling and bulkheading, rill stoping, and stoping with the use of frequent pillars, but whilst all of these served their purpose to some fair extent, none of them gave entire satisfaction. The underhand method was then experimented with, and was found from the start so safe and efficient that it has ever since been adopted as the standard method for the recovery of such classes of ore.

In the actual carrying out of the method, slight differences in procedure may be noted in different mines, but the general principles adhered to are in all cases the same. Briefly described, the method consists in taking out vertical strips or slices of ore, one set wide, and the full cross-section of the ore-body. Except when starting a stope on this method, each slice when taken out is paddocked off and filled up, so that only one strip of stope a set wide is open at any time. The result is that the least possible extent of back is left exposed, and any tendency for the old bottoms to crush down is reduced to a minimum.

In cases where the method is employed to work out the whole of a body of friable ore between two main levels the most approved practice is to deal with

the ground in short lifts. Thus, when the distance between the levels is 100 feet, it is worked out in two lifts of 50 feet each as in fig. 217. If the distance between levels is 150 feet, the mine manager will use his discretion in deciding whether it is best to work it in two 75-foot or three 50-foot lifts. In some circumstances it may be advantageous to use three lifts instead of two. The more lifts that are worked, the greater is the output, and, consequently, the speed with which the whole body of ore is removed; apart from that, it is

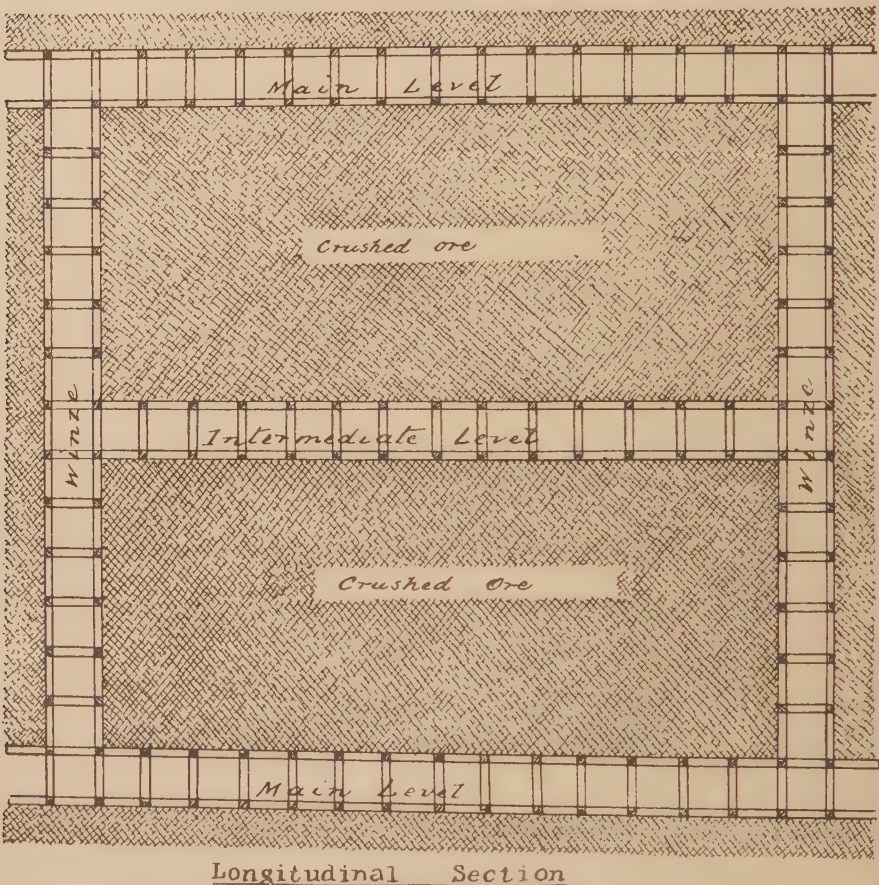


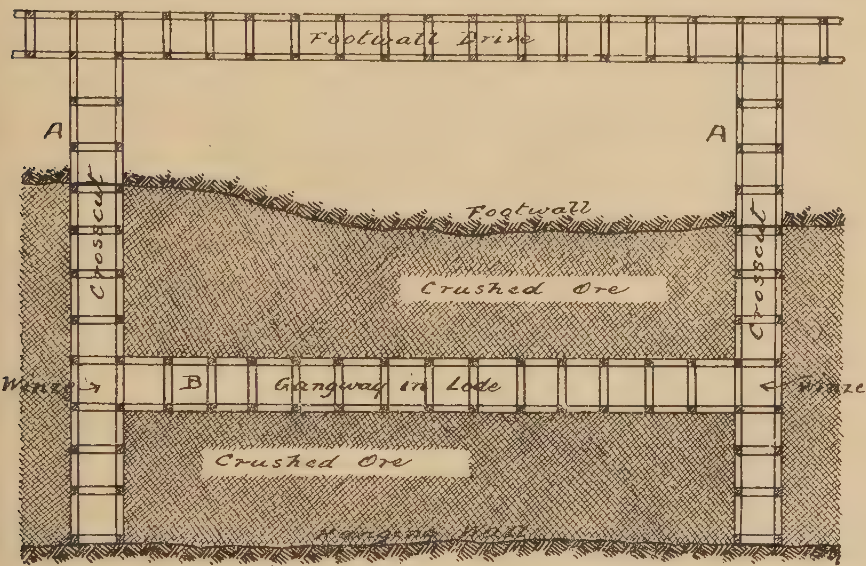
FIG. 217.—Preparing for underhand square-set stoping.

certain that the shorter the lifts are, the less is the liability of the timbering (the proper maintenance of which is the chief consideration) to be crushed or distorted, as it is only required to carry its burden for the least possible time. Whatever the number of lifts may be, the invariable practice is to work out one partially before proceeding to operate on the next beneath. Taking, for the purpose of illustration, the case of a mine in which the levels are 100 feet apart, the ideal method of opening out for underhand stoping would be as shown in figs. 217 and 218 which represent a vertical section and plan respectively. From a main level situated in the footwall country, crosscuts would be carried out, as at AA (fig. 218), at regular intervals, say of 100 feet, through

the ore-body, and would be connected by one or more drives B along the latter. From the crosscuts, winzes, sunk to the size of a full set, would connect the two levels together, and midway between the levels an intermediate would be driven to connect the winzes.

If the first slice of ore is to be taken out immediately under one of the crosscuts, the timber in the latter is picked up in some such way as shown in figs. 219 and 220. In the method shown in the first of these, four stringers of 10-inch by 10-inch timber are used, two of which are placed on the sills of the crosscut-sets, close to the posts, and the other two under the caps, with spreaders of similar-sized timber to keep them apart vertically and horizontally.

In the method shown in fig. 220 only one stringer is employed, this being



Plan

FIG. 218.—Preparing for underhand square-set stoping.

placed under the centre of the caps, and supported by *toms*. Spreaders are also placed between the legs of the level-sets, near the bottom, and wedged tightly. If it is at all possible to make use of it, the first described method is the most convenient to adopt owing to the placing of the timbers not obstructing the gangway. In all cases, the stringers are long enough to extend over at least three sets.

A start can now be made at the actual stoping by removing the ore from one of the sets immediately under the crosscut, as at A (fig. 221), and at the side of the winze that had been previously sunk.

As soon as room is made for it, a square-set is stood and supported by a boom, the manner of using which is shown with more detail in fig. 222. The two caps of the new set rest on the crosspiece A, usually of 10-inch by 6-inch timber, which in turn rests on the end of the boom B, of 10-inch by 10-inch timber. The boom itself is supported by the king-post C and is tailed back under the winze timber, as at D. The other members of the set are then hung either by strips of 10-inch by $2\frac{1}{2}$-inch board,

as shown in fig. 223, or by means of small iron dogs driven in at the corners, as in fig. 222.

This set having been placed in position, the next move is to take out the ore immediately beneath it and put in another set of timber, hanging it in the

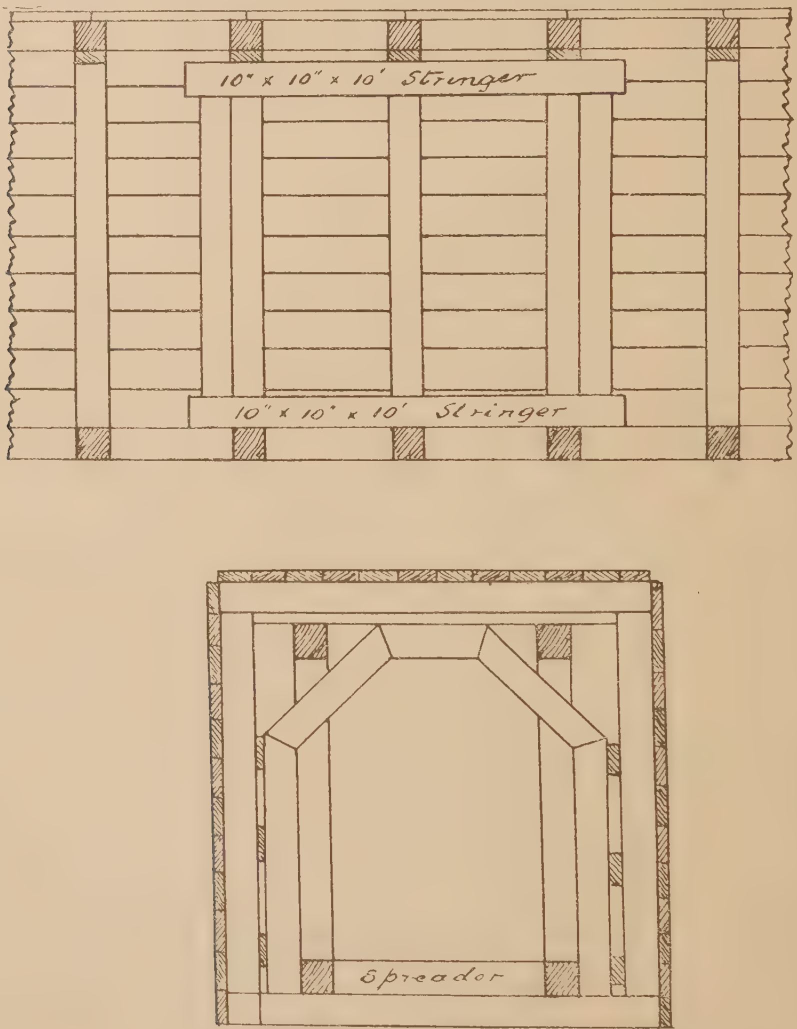


FIG. 219.—Picking up level-sets.

usual way to the set above, and so the work goes on, the ground being taken out and sets put in one under the other till the intermediate level is reached. As each set of timber is put in, it is blocked and wedged securely, with a view to taking weight off the hanging-boards or dogs as far as circumstances will admit.

The timbers of the vertical run of sets having been made secure, the boom under the first set erected may now be removed, and the stoping is continued by taking out the ore as at B (fig. 221), placing a set in, and booming it up in

the customary manner. The ore vertically under B is then worked out in the same way that under A had been, and the sets carried down to the intermediate level, and so the procedure continues till the wall is reached.

In the particular case illustrated, the hanging-wall would be first exposed.

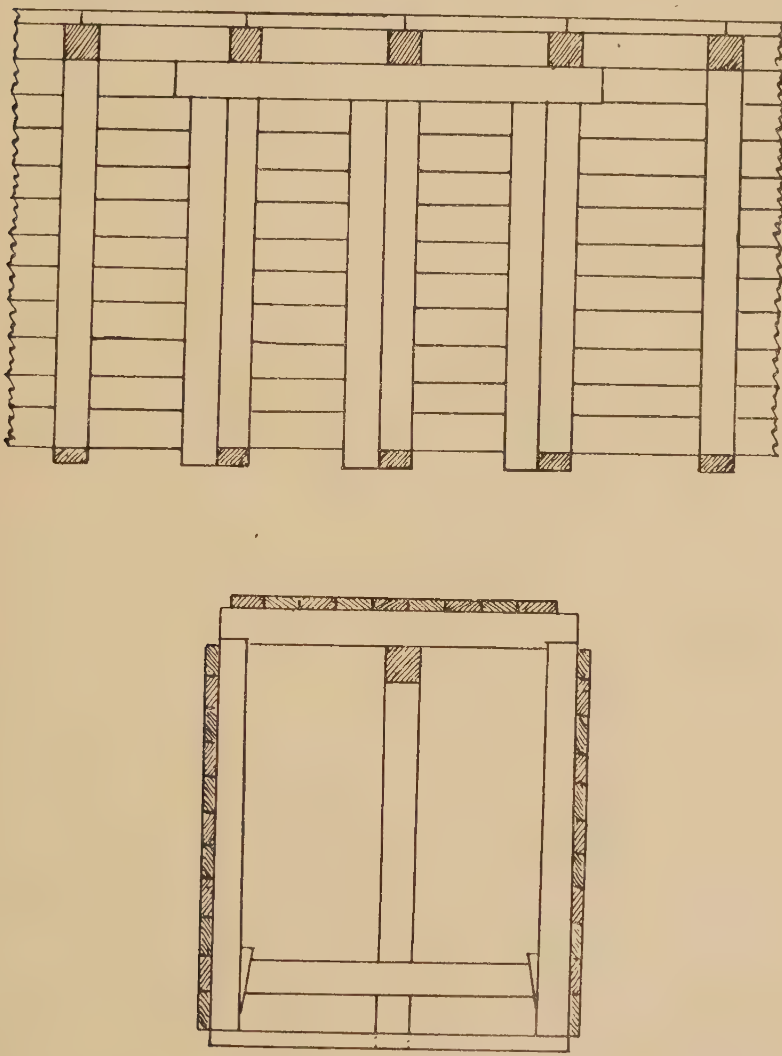


FIG. 220.—Picking up level timbers.

Should this be heavy, strengthening timbers such as shown in fig. 224 may be required in addition to the ordinary square-sets in order to support it adequately. When the one wall has been reached and properly timbered, a return is made to the winze, and the vertical stoping is extended in like manner to the other wall. If it is advisable that the whole work of removing the ore should be done quickly, it is possible to have men working simultaneously towards both walls, but a second pair of miners cannot be put in until work has been

extended to the opening of the vertical slice B, as otherwise they would not have room to set up the necessary boom.

When the complete slice of ore has been taken out right across the stope,

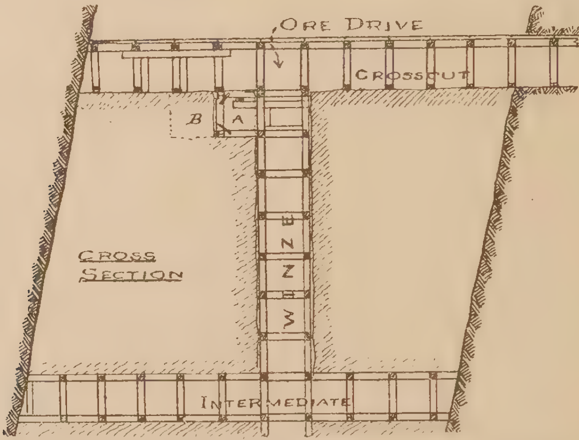


FIG. 221.—Underhand square-set stoping—method of procedure.

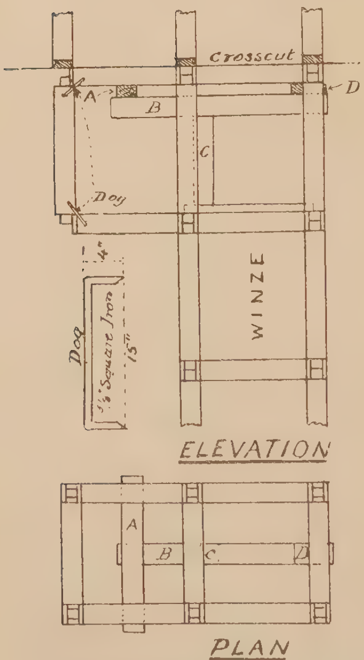


FIG. 222.—Showing use of boom in underhand square-set stoping.

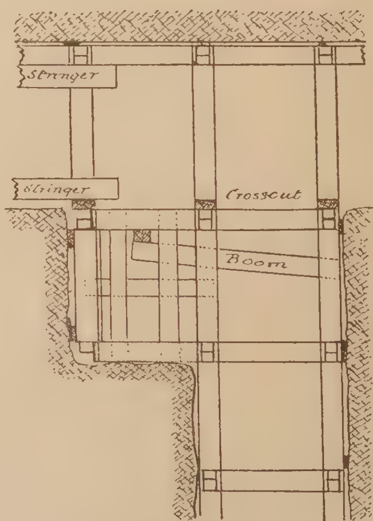


FIG. 223.—Method of hanging sets in underhand square-set stoping.

the next step is to take out a leading set as at X (fig. 225), which represents a section across the first complete vertical slice, to serve as an opening from which to attack the second transverse slice. Thereafter, the procedure is identical

with that in mining the first slice. By the time the first pair of men have removed the set X down to the intermediate level, and opened out a lateral set from it, the second pair will have completed the first slice on its footwall side, and will be ready to start work in the same direction on the new slice.

It may be well to point out that as each complete vertical one-set cut is carried down to the intermediate level, the timbers of the latter are extended in the direction of the full transverse slice that is being operated on, or, in other words, that on the intermediate level a gangway is opened across the stope under each separate slice.

In the case that is being illustrated, it has been explained that the first downward slice is taken out under the timber of the crosscut. To enable this to be done the picking-up timber has to be shifted along the crosscut as the work proceeds in the direction of the walls of the lode. The second slice to be removed will therefore be under ore *in situ* or under the floor of a filled stope

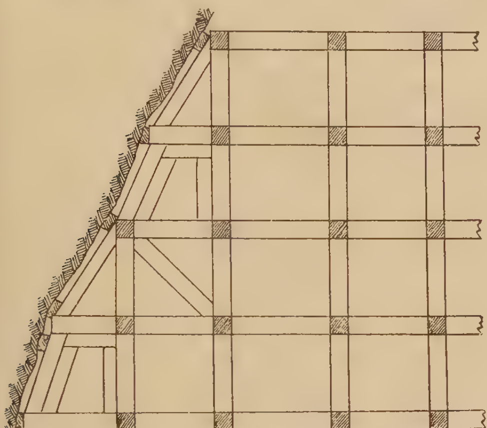


Fig. 224.—Closing sets to hanging-wall in underhand square-set stoping.

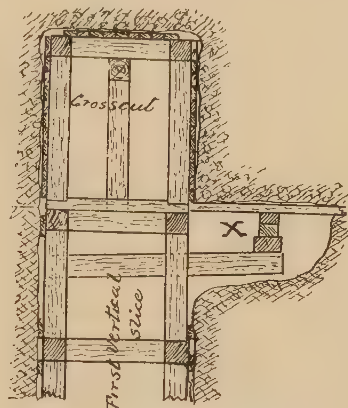


Fig. 225.—Section across first vertical slice, underhand square-set stope.

(excepting the strip through which the gangway connecting the crosscuts passes), consequently the removal of the leading set or any other top-set in a lateral direction has to be undertaken in a somewhat different way to the top-sets in the first slice, and usually calls for a good deal more care. If the set has to be taken out under an old floor, no very great difficulty need be experienced, provided the latter is in fairly sound condition and has been properly laid down. In such circumstances it may be quite possible to take out sufficient ore to enable a set of timber to be stood without any special precaution being taken to catch up the old stope. If, however, the old timber floor merely consists of odds and ends of timber carelessly thrown in place, or if the timber is badly decayed, this cannot be done. The procedure then is for the men to cut in cautiously under the old floor, as shown in fig. 225. As soon as room is made a boom is run out and placed in such a way that it will not need to be moved to allow the set to be put in. Once the floor is caught up in this way the rest of the ground can be taken out to enable the set to be stood and hung in the usual way, after which mining proceeds downward in the manner previously described.

In cases where there is no old floor to deal with, and the ground over the new leading set consists of crushed ore, a method similar to that followed when

driving in running ground must be resorted to in order to secure the back. Laths are advanced over the back of the adjoining set, as shown in fig. 226, an upward direction being given them by using a tail-piece. One man drives the laths while his mate loosens up with a pick the ore in front of their points. When all the laths are home, they are picked up in the usual way with a boom. In some instances side laths may also have to be driven, and coping-boards used. During the carrying out of this operation the firing of shots is avoided as far as possible. A large boulder of ore may occasionally have to be popped, but no more than one shot is ever fired at a time, and this is charged very lightly.

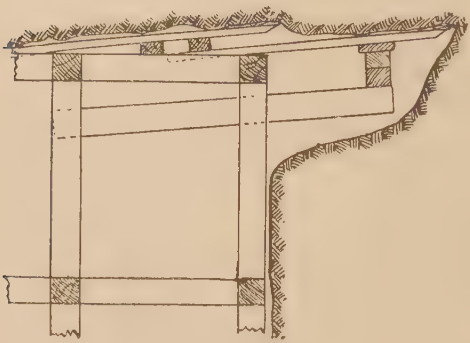


FIG. 226.—Booming leading-set under friable back.

A precautionary measure sometimes taken when there is danger of the backs running is that of laying a sollar in the top floor of the stope, as shown in fig. 227. Should a run take place, the back laths are driven home before any attempt is made to remove the material that has come away, and the boom is got into position without delay.

The stage at which filling up of the depleted stope is started is a matter for the discretion of the management. According to Fairweather (47), the practice observed in the South Broken Hill Mine when removing arches was to take out three full slices before running the first lot of filling in. If the back is very heavy, each slice may, however, be filled as it is completed, as in fig. 228, the leading cut being taken out first to give the miners the necessary opening from which to attack the next slice. The more often filling is carried out, the

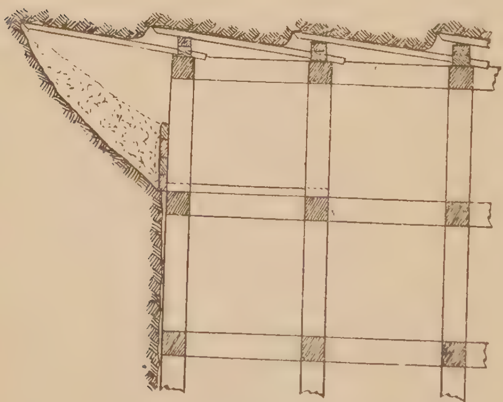
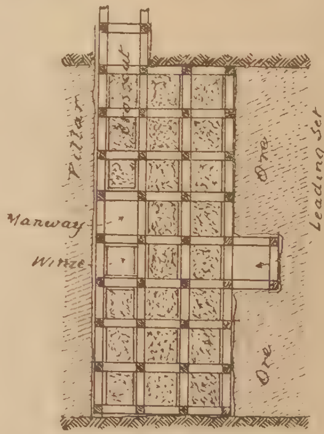


FIG. 227.—Preventing runs of ore from back.



PLAN

FIG. 228.—Showing method of extending underhand square-set stope along an ore-body.

costlier the work becomes, as the sets to be filled have to be paddocked off, necessitating the use of large quantities of planking. In any case, even if each slice is not filled directly it has been completed, it has to be filled eventually, and the filling has to be put in the entire slice at the one operation. This means that the whole face of the timber has to be completely lathed off to prevent the waste from mixing with the clean ore that has still to be recovered.

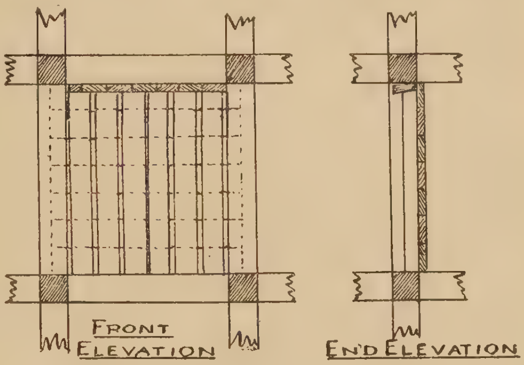


Fig. 229.—Paddocking-off sets for filling.

When another lift has to be worked below the intermediate level, a floor of timber must also be placed in the depleted section of stope. All openings such as the winzes, the intermediate level, and the cross-gangways in the latter have also to be planked. As a rule, the planking in the sets is placed horizontally, as shown in fig. 229, and, to strengthen it against pressure from the filling, vertical pieces of waste timber are wedged in outside it between the caps of the sets. If a filling pass is conveniently placed, the necessary filling can be run directly from it into the stope, but this cannot always be arranged, and, in any case, the whole stope cannot be filled in this way without a great amount of shovelling work. To enable the top-sets of the slice being filled with as little avoidable labour as possible, the filling is trucked from the pass and tipped down a temporary chute in the floor of the drive that has previously been put through the centre of the ore-body to connect the crosscuts into a truck placed in the top set of the stope, as in fig. 230, by means of which it can be delivered to the lateral extremities of the slice. By working in this way, all of the depleted stope save the top-sets of the slice can be filled up evenly and without undue trouble, but in filling the top-sets a certain amount of shovelling is unavoidable if the filling is to be packed well up to the backs.

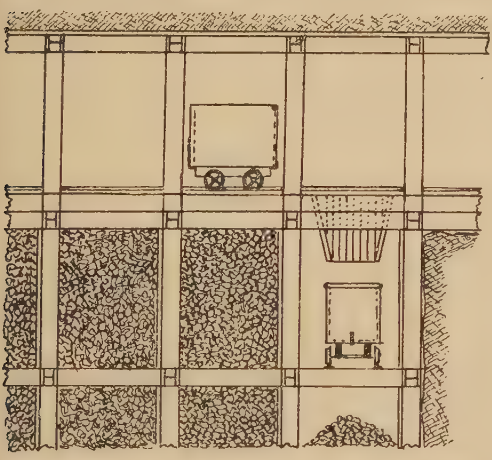


Fig. 230.—Method of filling underhand square-set stope.

CHAPTER IX.

TIMBERING WHEN REMOVING ARCHES OR BRIDGES.

It is usual in all mines, whether the ore-body be large or small, to leave a section of ore under the level for its protection. These sections may be anything from 6 feet thick, in a narrow lode, to 30 feet or more in a wide one, and they are known to miners as bridges or arches. If the lode material be of poor value, leaving only a narrow margin of profit over working expenses when broken out under normal conditions, the arch is not removed at all, and in some mines, even when the ore is fairly rich, it is allowed to remain permanently. In any case, the arches are not interfered with until that portion of the mine above them is exhausted, and there is no longer any useful purpose to be served by keeping the level immediately above them in good order. It sometimes happens that for transport, drainage, or ventilation, a level has to be kept open long after active mining operations have extended far below it; in such circumstances it is rarely advisable to remove the protecting arch from beneath it, for although wide arches are at times taken out without injury to the level, it is much more often found that, no matter how great care is exercised in taking out the ore and picking up the level timbers, the latter sink and are distorted and crushed to an extent rendering the working of very little good for any purpose afterwards.

TIMBERING WHEN REMOVING ARCHES IN NARROW STOPES.

In removing an arch in a small stope, especially if the lode has a fairly high angle of dip, little difficulty need be anticipated in carrying out the work. In the Blackwater Mine, at Waiuta, New Zealand, where the quartz vein has a dip of about 60 degrees, with a stoping width of from 3 feet to about 7 feet, and three-piece sets are used in the levels, the general custom is to leave an arch from 6 feet to 12 feet in depth. When it is desired to take this out a squared stringer sufficiently long to cover at least three sets is laid on the level close to the foot of the legs on the hanging-wall side, as shown in fig. 231. A hole is then bored with a 1-inch auger in each leg, flush with the top of the stringer, in which a short bar of round iron is inserted with its outer end projecting over the stringer and resting on it. A start is then made to remove the arch by putting up a small rise through it to connect with the level above, between the first and second set supported by the stringer. As the ore is removed, the ordinary two-piece or three-piece stoping-sets are carried up, the bottom of the hanging-wall leg of the level-set being caught up by the cap of the uppermost of them. When the stoping-sets do not come up directly under the level-sets, a bearer is laid across the caps of the second last line of stopers, as at A (fig. 232), upon which the leg or legs of the topmost set can be stood in such a position that the

cap will be directly under the foot of the level-set leg. Work is then carried forward in the direction of the next level-set secured by the stringer, each set thus being caught up in succession.

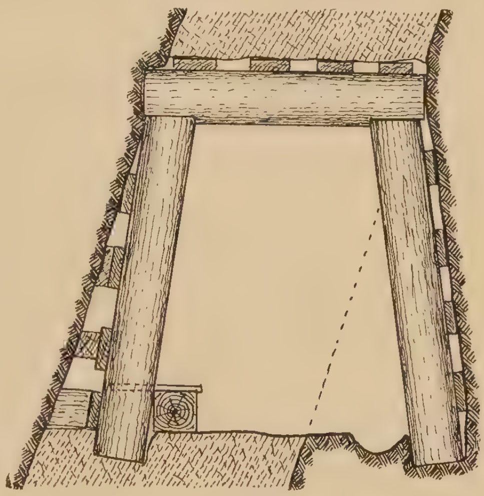


Fig. 231.—Picking up level timbers prior to removing an ore-bridge.

When the level-set legs that have been supported by the stringer have all been picked up as described, the latter is removed and shifted on to the next run of sets, when the same procedure as before is continued.

Although the hanging-wall is of loose-jointed greywacke, very liable to flake, and at times to become very heavy, little trouble is experienced in taking out all the ore safely and economically in this way, and it is seldom found necessary to run filling in until quite a long section of the arch has been mined. Before filling is put in, all the double passes (combined ore-chutes and travelling-ways) are timbered up to the level. These are spaced roughly at about 75 feet intervals along the stopes, with two single ore-passes equidistant between them. The single passes being no longer required are not timbered up, but are covered over and abandoned. The object in bringing the double passes through is to provide for ventilation. When filling of the stope is undertaken, the mullock is stowed carefully, but in spite of this the level-sets soon sink more or less, but as the level is seldom needed for transport purposes after the arch has been robbed, this sinking of the sets is not a matter of much moment.

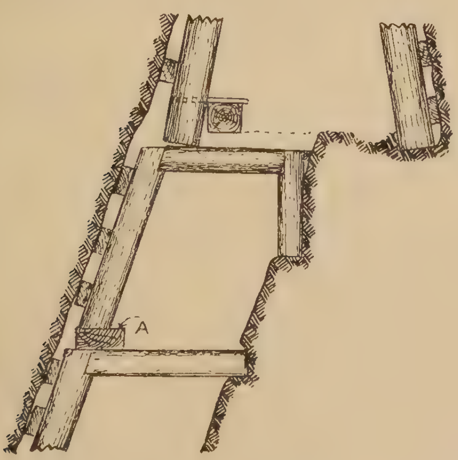


Fig. 232.—Taking up weight of level timbers as bridge is removed.

Instead of using the stringer and iron pins as described, in cases when it is not necessary to keep the level open for trucking, the legs of the sets are sometimes secured merely by driving stout spreaders between them, as in fig. 233. If the precaution is first taken to see that the lagging between the hanging-wall legs and the ground is wedged tightly, this method of securing the sets can be quite as effective as the one just described. The stoping-sets are carried up, and the level-set legs picked up with them in the same way as when the stringer is used, after which the spreaders may be removed for use elsewhere.

When the lode being worked is narrow and nearly vertical, and the arch

thus extends across under the level, the stringer method of supporting the level-sets can still be used, but a stringer will need to be placed at each side so that the two legs of each set may be caught up.

If the walls are not unduly heavy the simpler method shown in fig. 234 may prove quite as effective. Notches are cut in each leg a few inches above the level of the rails, and in these the spreader is set, having previously been prepared with bevelled ends to fit neatly. Wedges are then driven at the ends

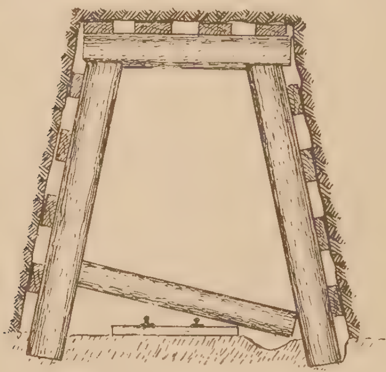


Fig. 233.—Picking up level timbers by spreading legs of sets.

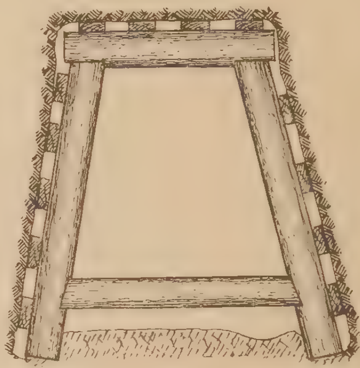


Fig. 234.—Picking up level timbers by spreading legs of sets.

between the spreader and the legs, and the whole set in this way made as rigid as possible. Unless considerable back-weight is exerted against it, a set secured in this manner is little liable to shift during the short period in which it is left otherwise unsupported. Only one set at a time should have the ore removed from under it, and the legs should be caught up from below as speedily as circumstances admit.

Where back-weight is likely to be troublesome, effective support, in addition

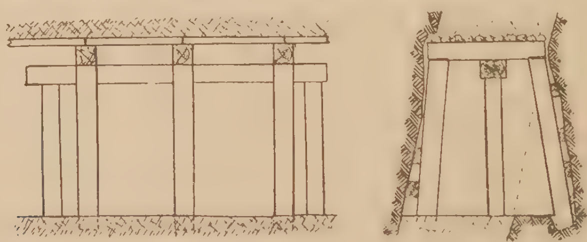


Fig. 235.—Picking up level timbers by means of stringers under caps.

to the spreader, may be afforded to the set by using a boom, as in fig. 235. This is placed along the centre of the level against the underside of the caps of the sets, and supported on *toms* at each end, and also, if thought necessary, at the middle.

When a level is being timbered, and it is known at the time that the ore beneath it will later on have to be taken out, it is advisable to stand the sets on mud-sills, as these are a great help subsequently in picking up the timbers. This is particularly the case when the stoping is not done with regular sets by means of which any weight there may be on the level-set can be readily taken up.

Another method of removing an arch in a small stope is that shown in

fig. 236. This has been described by Godfrey (13), from whose paper the accompanying illustration has been taken. In following this plan, the stope is worked upwards towards the level until within about 6 feet of breaking through. Filling is then sent down, and the working packed with it up to the backs. The level timbers are next picked up by a boom, and, if necessary, spreaders, and a start is made to remove the remaining ore by opening out on it from a winze or rise. Going carefully to work, the miners break away the ore under one of the level-sets, and if no sill had previously been put in, they now introduce one, and under this, with its ends resting on either side of the opening, a bearer A is placed. Should the occasion demand, this bearer is in turn supported by a *tom* stood on a foot-block placed on the stope-filling. As the bearer may interfere with the convenient movements of the workmen, it is sometimes best to catch the level-set legs up merely by means of the sill and a pair of *toms*. As soon as sufficient ore has been removed to admit of filling being put in, the latter is packed well under the sill, the *toms* being left in place as an additional support.

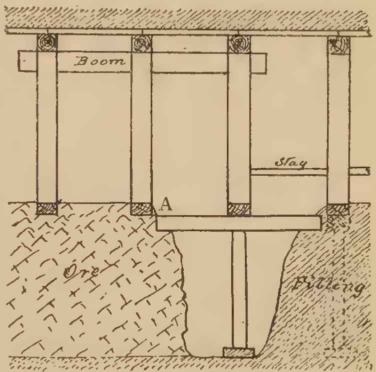


FIG. 236.—Supporting level-sets during bridge removal.

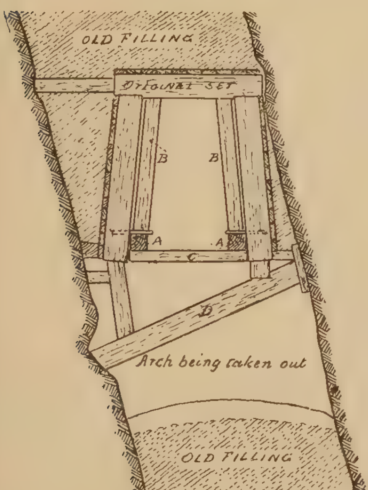


FIG. 237.—Method of picking up level during removal of bridge as followed at the Waihi Mine, New Zealand.

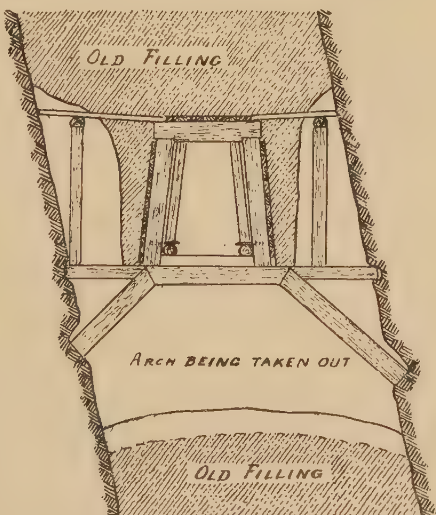


FIG. 238.—Another Waihi method of supporting level timbers during bridge-removal operations.

In the well-known Waihi Mine, New Zealand, a method of timbering under similar circumstances, differing only slightly from the foregoing has been employed when dealing with lodes of small size. This has been described by Gilmour and Johnston (43), and is shown in fig. 237, which, together with the two following illustrations (figs. 238, 239), has been adapted from their interesting

paper. Two stringers AA are laid in the level close to the sets, and holes are bored in the legs, into which iron pins are inserted in exactly the same way as in the Blackwater Mine method. Between these pins and the caps of the level-sets pieces of timber BB are wedged tightly to take the full weight of the caps, and a spreader C is placed between them at their lower ends to prevent any danger of the legs coming together. The ore immediately beneath the set is then removed, and a stull D is put in, from which the level-set legs are securely blocked. As in the method just previously described, the stope is filled to the backs before the arch is interfered with. When the sets that have been supported by the stringers have all been caught up, the latter are shifted on to the next succeeding sets.

According to the authorities mentioned, this method of using a single stull from which to pick up the level-sets has been employed with very satisfactory results in workings up to 15 feet wide, but for stopes from this width up to 20 feet, while much the same general line of action was followed, it was found that the length required in the stull was inconvenient, and the use of a saddle-back set, such as shown in fig. 238, was relied on. This saddle-back consisted of two legs hitched into the stope walls, with a cap or key-piece between them. It will be noted that to enable this method to be effectively employed a bench of ore was left alongside the level when the latter was driven. This bench can be taken out, if desired, during the arch-removal operation, once the level timbers have been securely picked up, but, in case sollars had not been laid under the filling in the stope overhead, it is better policy to leave this portion undisturbed.

TIMBERING WHEN REMOVING ARCHES IN WIDE STOPES.

In wider stopes, other methods have to be resorted to. The Broken Hill method has already been described, and need not be further dealt with, but various others have been made use of that deserve mention.

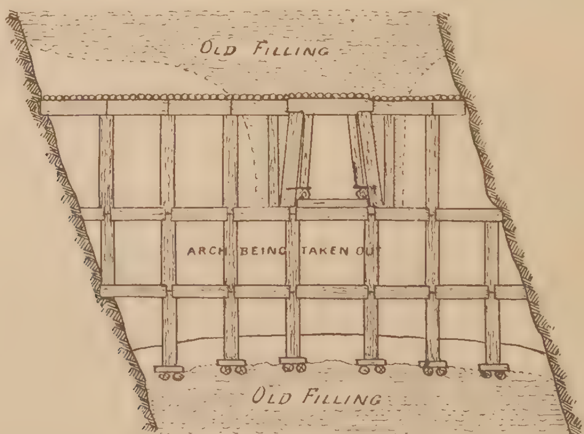


FIG. 239.—Waihi method of picking up level timbers in wide lode, when removing an ore-bridge.

One of these, adopted in the Waihi Mine, is illustrated in fig. 239. Here the bridge was removed by overhand stoping, the sets being started from sills bedded on the filling. Sufficient room was left between the latter and the backs

to admit of the ore as it was broken being delivered to the pass previously brought up through the filling, and the work of removal was proceeded with by taking the ore out in vertical slices across the arch from wall to wall rather than in the usual horizontal slices. The level-sets were first picked up in the customary way, after which a rise to the size of a full set was put up through the arch immediately at one side of the level, or directly under it. In the latter case, the level-sets were caught up by the topmost set of the rise timber. Winging off the ore in a lateral direction was then begun at the bottom of the arch by taking out a set of ground at the side of the rise. If the ore was of good standing character the whole bottom slice might then be taken to the

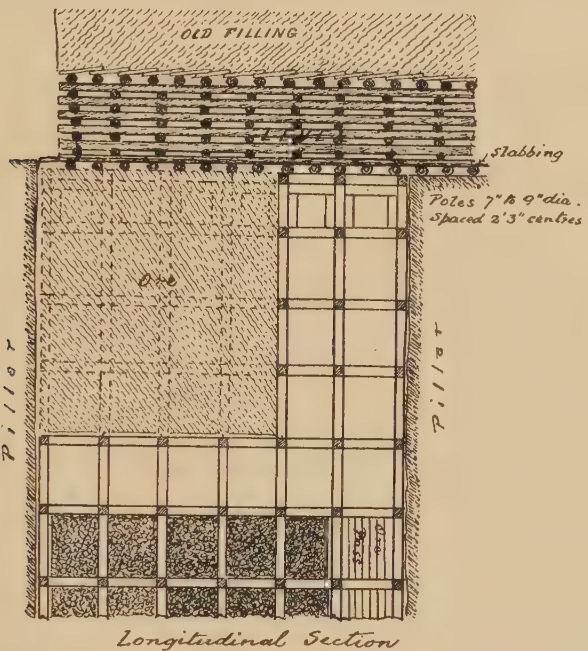


FIG. 240.—Picking up level when removing ore-bridge, Mt. Morgan Mine, Queensland.

height of a set from wall to wall, but where there was any pressure the safest plan of working was found to be that of working out each set vertically upwards to the level in exactly the same way as if each were a separate rise. If benches of ore had been left at the sides of the level the stoping can be carried up in such a manner that only remnants of them need remain undisturbed.

In the Mt. Morgan Mine, Queensland, the bottoms under the old bulk-headed stopes were picked up with square-sets. In this mine the lode was very wide, and to a great extent the stoping was done in sections, that is, only a certain area of lode was operated on at any one time. Frequently pillars of ore were left on either side of the section being worked. The method of working out the upper portion of a section, and catching up the timbered floor of the filled stope above, is shown in fig. 240. The old stopes before being filled were floored by first laying down long stringers about 2 feet apart, and then covering them with a double layer of 9-inch by 2-inch slabbing. When the stope below had reached to within from 30 feet to 40 feet of this floor, it was

filled up to within about 6 feet of the backs. A slice of ore two sets wide was then taken out completely across the stoping section and up to the old bottoms, each set of timber being stood as soon as room had been made for it. The taking off of this slice was started from a rise connecting with the level above. Each separate floor of the square-setting could be taken off in succession from the lowest point of the arch upwards, but as the stringers under the old bottoms were reached only one set of ground at a time was opened, and the stringers were picked up securely before the next set was mined. When the double slice was completed, one-half of it for the full width and height was paddocked off and filled, the mullock in the top sets being hand-packed. Careful packing of the filling was found to help greatly in preventing subsidence of the old floor, but to assist it in this direction the last lines of sets put in under the stringers were strongly reinforced, as shown. On the square-set floor from which the removal of the arch was started, temporary openings were left along the centre line of the stope to permit of the broken ore being trucked to the passes; these, when no longer required, were also filled. Little or no

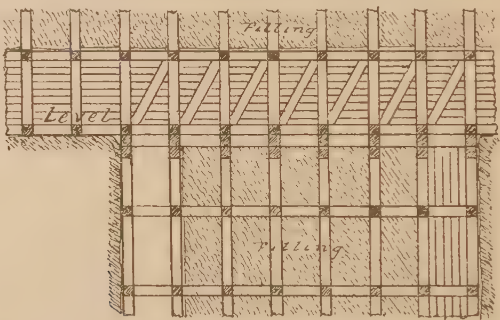


FIG. 241.—Another M't. Morgan method of picking up level timbers.

difficulty was experienced in picking up bottoms laid down as described, the long stringers giving splendid support to the old filling, and if the work were done carefully very little subsidence took place.

In the same mine, when the floor to be picked up was square-setted, much the same procedure was followed, but the timbers of the level above were usually strengthened by the insertion of diagonal braces, as in fig. 241. The sets under the sill floor were either reinforced as in fig. 240, or by being provided with double caps.

When picking up an old filled, square-setted stope, it is not necessary that the sets of the new stope that is being brought through need be in perfect alignment with those of the stope above. The fact that the sets are not vertically one under the other will not prevent the picking-up being carried out safely and effectively, but it is an advantage if they are in vertical alignment, and it is a further help if long mud-sills had been placed on the old sill floor.

In catching up old bottoms in this way the last sets of timber put in under the old stope floor are not necessarily prepared in accordance with the method usually followed in the mine. Spills on the posts may be done away with, and the ordinary caps and struts replaced by those of the clap-me-down set type, with stays between them. The posts may also have to be cut to special lengths to fit in neatly. Any spaces between the caps and the old bottoms are filled with blocks and wedges. If the new sets come up in good line with the

old, it may be possible to dispense with caps on the uppermost, the posts being stood so as to pick up the old sills directly, but this ideal condition is rarely experienced, and in any case the more common practice is to use caps, if only for the extra support they afford. Picking-up work of this nature should

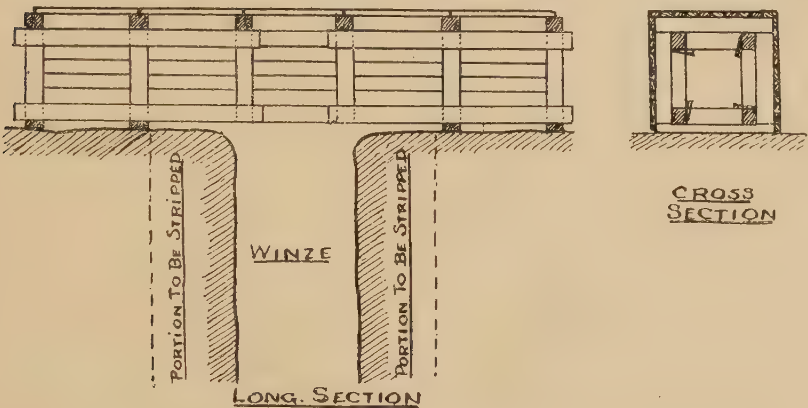


Fig. 242.—A Broken Hill (Australia) method of securing level timbers when opening out for underhand stoping.

never be entrusted to other than experienced men, for a good deal of care is required in carrying it out, and workmen accustomed to it are better prepared than others to meet the many contingencies that arise.

Although the Broken Hill methods of timbering when removing arches have

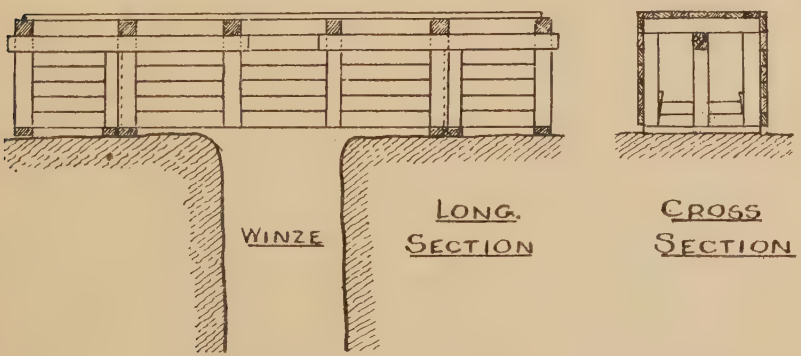


Fig. 243.—Another Broken Hill method of picking up level timbers.

been described, reference may be made to certain variations in procedure mentioned by Fairweather (47) as followed in the South Broken Hill Mine. In that mine, when an arch was being taken out after open stoping, the back of the stope was levelled off, and the stope itself was filled, with the exception of a space a set high in which square-sets were built up on the filling under the whole section of arch. Through these sets a gangway was left to give access to ore-chutes and ladder-ways to the level below. All the other sets, after being wedged tightly to back and sides, were then also filled.

A winze of the size of two full sets was next sunk to the filling. Where

a one-set winze already existed, this was stripped down to two-set size, the lengthening being done as shown in fig. 242 by taking a portion of ore out on each end of it. The gangway above was first picked up in some such way as shown in fig. 242 or fig. 243, after which, dependent on the nature of the ground, the stripping and retimbering was done in one or other of three ways. Pro-

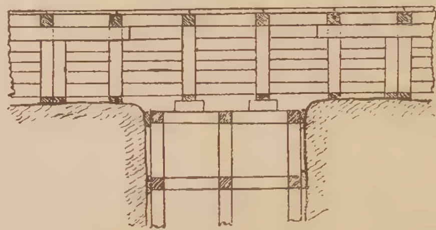


FIG. 244.—Timbering winze in bridge removal operations.

viding the ground was of fairly good standing character, the whole winze was stripped right down to the buried timber below and was timbered from the bottom upwards to the level in one operation. This method is shown in fig. 244. Any spaces that were left between the caps of the top-sets and the sills of the gangway were filled with suitable blocking. If the ground was not

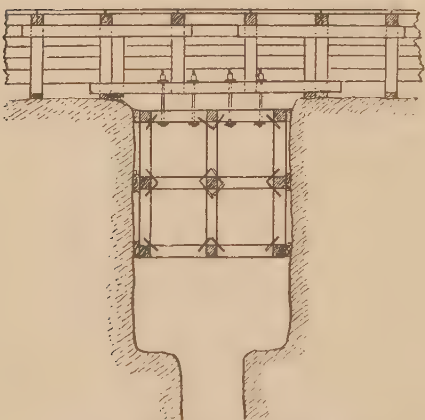


FIG. 245.—Hanging winze-sets in bridge removal operations.

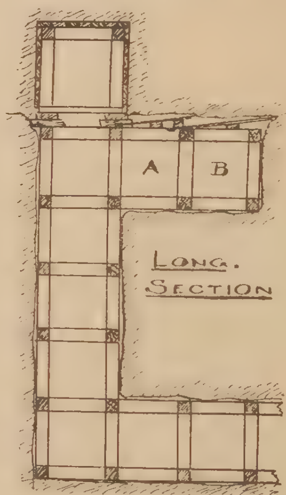


FIG. 246.—Mode of procedure in removing ore-bridge, South Broken Hill Mine, N.S.W.

sufficiently strong to stand up in the way mentioned, the stripping was still carried out from the top downwards, but sets were placed in as room was made for them, and hung, as shown in fig. 245, from bearers placed along the gangway on the sills. Only the first sets were suspended directly from the bearers, the succeeding ones being hung by means of iron dogs driven into caps and posts near the corners. The third method was to rise the enlarged winze from the gangway left in the stope beneath, the sets being erected as the ore was removed. The winze having been completed, the rest of the arch-removal work proceeded in the manner previously described, with this exception, that when the leading

sets had to be taken under a bad bottom, that is, one in which there were no sollars at all, or these had decayed, instead of one leading stope being taken out in advance of the slice being operated on, two were invariably opened and boomed, as at A and B (fig. 246). This precaution was taken with a view to lessening the danger of runs of filling from overhead.

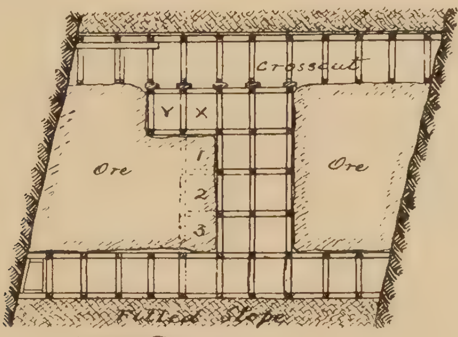


FIG. 247.—Mode of procedure in removing ore-bridge, South Broken Hill Mine.

When a slice was being extended laterally, the same course was followed. Thus, if X (fig. 247) represented a set in a slice that was being mined, the set Y would be opened out and boomed before sets 1, 2, and 3 were touched. The advantages claimed for this method of procedure are that as the second advance or leading set under the old bottoms, whether in the lead or the

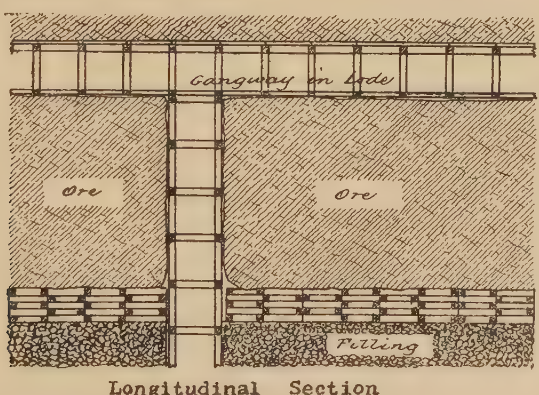


FIG. 248.—Timbering when removing ore-bridge.

wings, stands on fairly solid ground when the first set in either direction is being unfooted, should a run occur in say A (fig. 246) or X (fig. 247), the sets B or Y respectively can be used for booming them, and that the fact that A or X is in solid ground prevents any serious runs.

Another variation in practice in stoping out arches is that of erecting bulks solidly under the arch, instead of square-sets, and filling them with waste rock or sand. The bulks are put in much as shown in fig. 248. Gangways are left between the bulks to give access to manways and ore-chutes, and the removal of the arch is then proceeded with in the same manner as already described—

that is, by working from the top downward and taking the ore out in slices across the stope. The bottom sets of each slice may be bedded on the bulks, or on sills placed on the filling, the bulks being taken away in their order to admit of this being done. Fig. 249 will serve to give a general idea of the

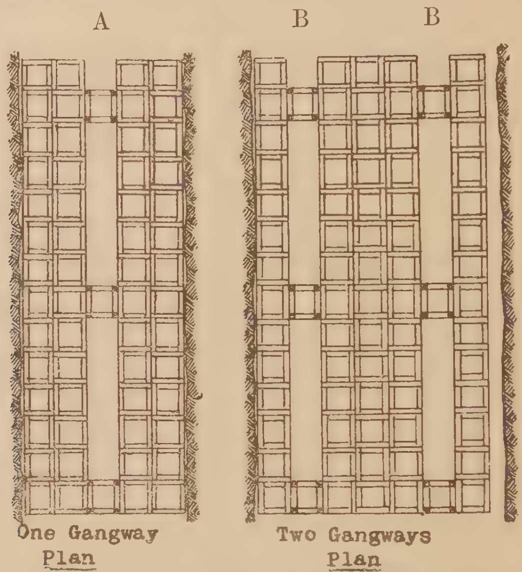


FIG. 249.—Timbering when removing ore-bridge.

arrangement of the bulks in plan. If the stope is only of moderate width, it may be sufficient to provide one gangway in it, as at A, but if it is too wide to admit of ready removal of the broken ore a gangway may be left towards each wall, as at B. The bulks are built up of squared timbers, usually 10 inches by 10 inches, much of which may be recovered, if desired, for future use.

CHAPTER X.

TIMBERING RISES, MANWAYS, AND ORE-PASSES.

TIMBERING DEVELOPMENT RISES.

THE method adopted in any mine for timbering rises is determined by such factors as the size of the lode that is being worked, the nature of the ground, the purpose the rise is to serve, and the quantity and quality of the timber available. In such circumstances as when the lode is large or vertical, when the ground is firm, when the rise is to be subsequently used as a permanent ore-chute, or when timber is plentiful and cheap, it may be possible, and even necessary, to follow quite different methods than would be called for when the lode is small or flat, when the ground is weak, when the rise is only meant to serve a temporary purpose or when timber is scarce and costly. In some countries the law has something to say in the matter also, as, for instance, in New Zealand, where mining legislation prohibits the putting up of a rise to a greater height than 30 feet unless it has at least three compartments.

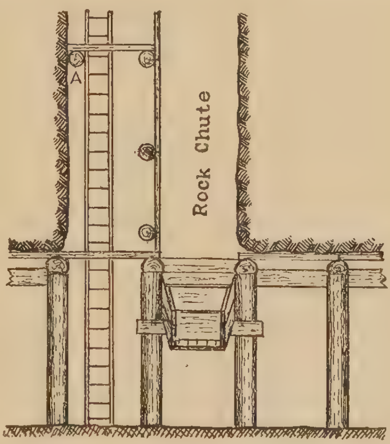


FIG. 250.—Timbering two-compartment rise with stulls, in hard rock.

Throughout Australasia it is still not uncommon to see two-compartment, and even one-compartment, rises put up, but where a rise is to be extended to any considerable height, and serve purely development purposes, the prevailing practice is to make it with three compartments. In the United States of America lengthy two-compartment rises have been put up within recent years, and probably will continue to be put up, but the modern tendency is to adopt the three-compartment type. There can be no doubt that whatever other beneficial results follow the provision of a third compartment it has the effect of ensuring better ventilation, and, consequently, healthier working conditions for the men engaged in rising.

In comparatively small mines, the timbering of a rise may be a very simple matter when the walls are fairly strong. If the rise has two compartments all that may be necessary is the putting in of a line of stulls, as in fig. 250, which are lagged to separate the ladder-way from the rock-chute. The stulls are spaced about 5 feet apart, and in work of this kind it is not customary to use head-boards, but to hitch the timbers into the walls. To ensure a tight fit,

the hitches are prepared first, so that the stulls can be cut to exact length. Should there be inequalities in the size of the stulls, the latter should be aligned on the rock-chute side to provide a good face on which to secure the lagging. To enable stages for ladders to be fixed, stulls of smaller diameter should be set as at A, at regular intervals in the ladder-way. These intervals must be regulated by the length of the ladders to be used, and may be from 10 feet to 20 feet, but if the rise is inclined, as when following the underlay of a lode, it may be necessary to put them much closer together to admit of the provision of a skid-way for the convenient hauling up of timber, tools, etc.

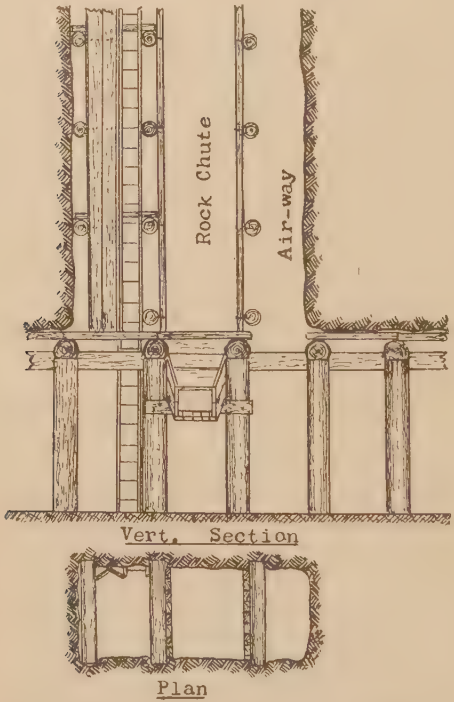


FIG. 251. - Timbering three-compartment rise with stulls, in hard rock.

In the same class of country, a three-compartment rise may be timbered in much the same way as shown in fig. 251. It merely means that a further line of stulls needs to be put in. Of the three compartments thus formed, the central one is used as a rock-chute, and the others as an airway and ladder-way respectively. In the illustration the airway is 2 feet in length, but a narrower opening, say of 1 foot, will usually suffice for ventilating purposes. The lagging used to form the rock-chute - is generally of 8-inch by 2-inch material, and is long enough to enable each piece to be spiked to at least three of the stulls; if short lengths are used just to span from stull to stull they are very liable to be torn away by falling rock. The central rock-chute is kept lagged up to within a few feet of the top of the rise at all times, and when the men are drilling or blasting, the airway and ladder-way are kept securely covered. Head - boards of stout timber, say 8 inches by 4 inches, are used for this purpose, as they afford the only protection to the men when getting away from a blast or returning to the top of the rise after a blast, and they have to withstand heavy shocks from the blasting, especially when the cut is being fired. In order to preserve the lagging of the rock-chute as much as possible, the latter is kept at all times nearly filled, only enough rock being drawn off to make room for such as may be broken out by a fresh blast.

Several methods of timbering small rises which it is intended to open out later to shaft size have been described in the section of this work dealing with shaft timbering, and need not be again detailed here.

When putting up a rise in ground that is liable to flake it may be necessary to box-timber it, that is, to line it more or less closely with sets of timber. The method adopted in all the mines on the West Coast of New Zealand in this class of country is shown in fig. 252. These rises are not put up of very large

size, about 7 feet by 3 feet in the clear being the usual dimensions, and they are invariably on the dip of the reef. A rise of the size mentioned would be divided into three compartments of 3 feet, 3 feet, and 8 inches respectively, and the rock-chute placed at one end, with the airway at the other. The dividers between the airway and ladder-way are of 8-inch by 3-inch timber, but all the rest is 8 inches by 4 inches. The airway may seem narrow, but on this field the width mentioned has been found sufficient for its purpose. The sets of timber are placed directly one on another, no chocks being used. In most of the mines the end- and wall-plates are halved at their ends to make a joint, and where split slabs are used this is always done, but when sawn timber is employed the custom is becoming more and more general of cutting the ends of all the timbers straight, no scarf or check of any kind being cut in them. The end-plates are merely placed between the side-plates, and secured to them by drift-nailing, though in some instances vertical cleats are also nailed in the corners. The dividers are secured in the same way. The available timber (local beech) is of indifferent quality, and it was found that any checking of it rendered it much more liable to be split by the considerable pressures exerted by the walls than was otherwise the case, hence the adoption of this method.

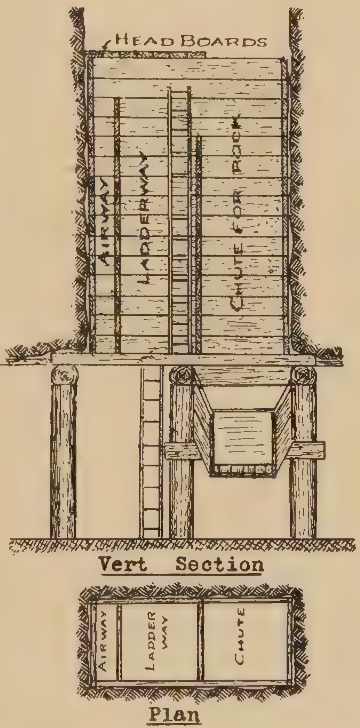


FIG. 252.—Three-compartment boxed rise.

The timbering of rises of this description is carried out as follows: In the first place a cut about 6 feet in height is made for the full size of the rise, then a further 6 feet of ground is bored out. The timbering is then started as shown in figs. 252 and 253, and carried closely up to the back, the dividers between the airway and ladder-way being brought up to within a few inches of the top, and those between the ladder-way and rock-chute to within about 3 feet. This latter provision is to admit of the men passing through under the head-boards. When this section of timbering is completed, the head-boards are placed over the airway and ladder-way, and the 6 feet of ground previously bored is blasted out. The rock from this round of holes having been cleaned up, a further 6 feet of the rise is bored out, and the timber once more brought up to the back, and so the work proceeds. In the manway, a skid is provided for the convenient haulage of the timber up the rise, and a small air-hoist is used. The hoist is set in a cuddy or recess cut in the level immediately opposite the ladder-way, as in fig. 253. At the top of the rise a temporary gin-pole is hitched into the walls at each separate timbering to carry a pulley through which the rope from the hoist passes.

The lip of the chute usually projects into the drive as far as the nearest rail of the tram-line.

When rising in a mine in which square-setting is the customary method

of timbering, much the same procedure is followed. In this case, however, instead of the timbering being started from the back of the level it is started on the sill floor, usually from an offset at the side of a gangway. What may be described as the standard square-set rise is a regular six-post two-compartment combination of rock-chute and manway. In other words, the rise is made to

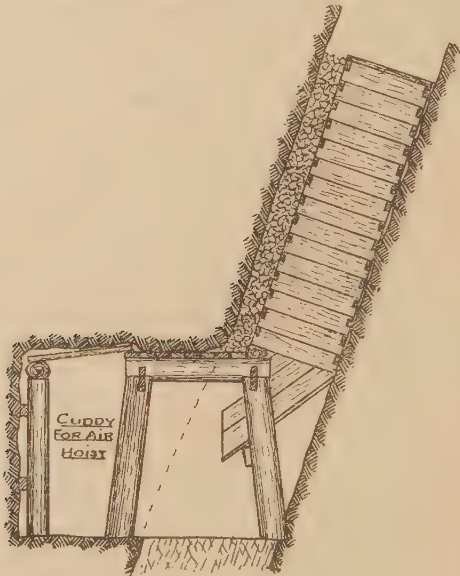


FIG. 253.—Boxed rise in narrow lode.

the size of two full sets, one of which is lagged off as a rock-chute, and the other used as a travelling-way for the men. If desired, the latter can be further temporarily divided into two compartments the better to provide for ventilation. The lagging used to form the rock-chute is usually 3 inches thick, but if the rise is not long 2-inch material may suffice. The lagging is spiked to the inside faces of the sets forming the chute, and is usually put on in lengths reaching from centre to centre of the respective caps or struts.

TIMBERING ORE-PASSES AND MANWAYS IN NARROW LODES.

In small mines, the timbering of ore-passes or manways carried up during stoping operations follows much the same lines as those adopted in development rises, with slight variations to meet the different conditions. In some it is customary to make all the stope-passes with two compartments, one to serve as a manway and the other as an ore-pass. The more general practice is, however, only to bring up two-compartment passes at regular intervals, with single passes between them. These single passes may, if necessary, be used as manways, but they are usually employed as ore-passes only. In the Reefton district, New Zealand, in such mines as the Blackwater, where the reef is narrow, the practice is to rear double passes at intervals along the lode, of about 75 feet, with two single passes equidistant between them, and in some of the large Broken Hill mines in Australia single and double passes are alternated in the same way.

If stull timbering is the method general in the mine, the passes are formed as shown in fig. 254 in the case of a double pass, or by merely putting in two stulls in each row in the case of a single pass. In a double pass the centre vertical stulls are aligned on the ore-pass side, so that when the dividing lagging is spiked to them it will present an even face.

In similar small workings, when box-timbering is employed, the passes are

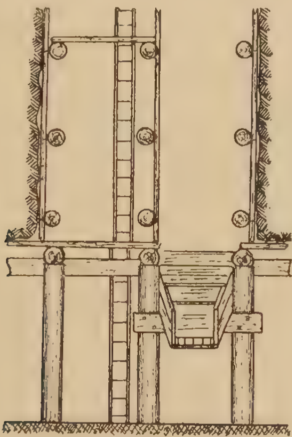


FIG. 254.—Two-compartment rise, timbered with stulls.

started as shown in figs. 252 and 253. The plates and dividers may be scarfed or cut square on the ends, as preferred. The passes are invariably started on the footwall, and they follow the dip of the lode, and are reared up in sections of about 6 feet as the stope progresses upward.

TIMBERING AT BENDS IN ORE-PASSES, ETC.

It is rarely possible to bring passes up in the one vertical plane, either owing to rolls in the dip of the lode or to dislocations due to faulting. The passes are

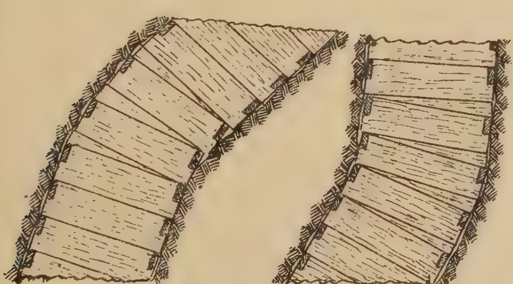


FIG. 255.—Timbering rises at bends.

FIG. 256.—Showing improper way of timbering a boxed rise at bends.

kept as far as possible in the lode, and this means that when a serious roll takes place, or dislocation is encountered, they have to be thrown to one side or the other, and on each occasion a bend is introduced. In timbering these bends it is advisable, in order to get the best service from the timber, and maintain

the full width of the opening, to keep the " lay " of the sets as nearly as possible at right angles to the walls. This is effected either by placing lifting chocks under one side or other of the set of timber or by inserting triangular pieces as shown in fig. 255. If instead of the timbers being raised in this way they are put in in the same plane as before the bend is reached, as in fig. 256, a narrowing of the pass is brought about which may cause much trouble later on owing to the ore hanging up; the footwall plates are also subjected to an undue amount of wear, and, at the same time, should any considerable pressure be exerted by the hanging-wall, as is usually the case, the timbers are not in a position to offer the same degree of resistance to it as they would if set more directly at right angles to the wall.

In some mines round poles are used in place of sawn or split timber in constructing passes of this kind. They are usually laid skin to skin, with the ends halved to make the corner joints. The dividers may also be halved (see fig. 6), or may be merely set between the side-plates and held in place with battens.

TIMBERING ORE-PASSES AND MANWAYS IN WIDE LODES.

In many of the older Australian mines it was quite common for ore-passes in both small and large lodes to be formed of rough logs, slightly joggled near the ends, as shown in fig. 257.

Owing to the spaces that would have to be left between the dividers, it was not safe or convenient to construct double passes in this way, the danger of

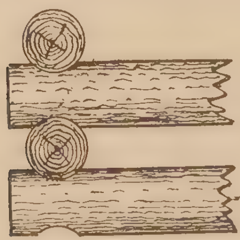


Fig. 257.—Pigsty method of timbering an ore-pass.

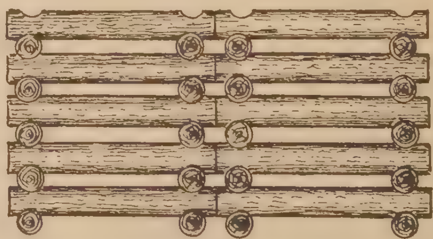


Fig. 258.—Double pass constructed on pigsty method.

stone trickling through into the manway, to the injury of the miners, being too great. Consequently, when it was desired to bring up a manway and ore-pass side by side it was done by building up two of these cribs independently, as in fig. 258.

In wide lodes a variety of methods of forming ore-passes and manways have been followed. In the Progress Mine, Reefton, New Zealand, the custom was to build the double passes of sets of sawn or split timber of about 8-inch by 4-inch cross-section, stood on the narrow edge, but instead of placing them parallel to the strike of the ore-body, as is the usual practice, they were erected with their long sides across the lode, as in fig. 259. For many years the ordinary method of placing them with their longer side in line with the walls had been followed, but such was the effect of the pressure on the timber that constant repairs were necessary, and it was only with great difficulty the passes could be kept open at all after the stopes had been carried up a short distance. To avoid excessive repair costs, the plan of placing the ore-passes lengthwise across the stope was tried, and it gave such satisfaction that it was subsequently exclusively followed in all the heavier stopes. For obvious reasons, the foot-

wall compartment was always used as the ore-pass, and in the manway the ladders were set against the dividers instead of against the wall-plates, as would otherwise have been the case.

The starting of a pass of this kind presented no difficulties. Fig. 260 shows the way in which it was usually carried out. A stout bearer was laid across the caps of the level-sets, and another on the footwall, and on these the starting

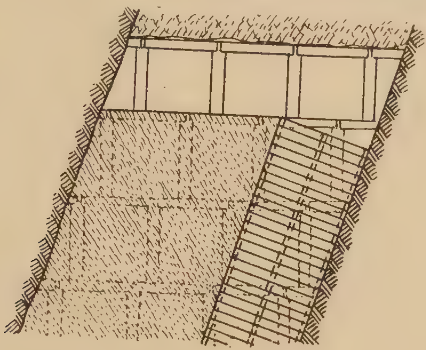


FIG. 259.—Double ore-pass placed with longer axis across stope.

set of timber was placed. Where the footwall was strong, the bearer on that end could be dispensed with.

In the case of a lode of moderate width an ore-pass of the type shown in fig. 261 has been described by Warren (7) as giving good service, especially where the footwall is strong and much heavy use is expected of the chute. In all inclined ore-passes, the first timbers to be cut out are those on the footwall,

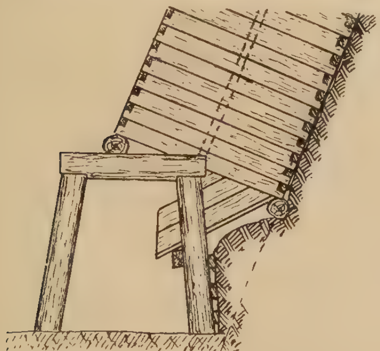


FIG. 260.—Starting double-pass shown in fig. 259.

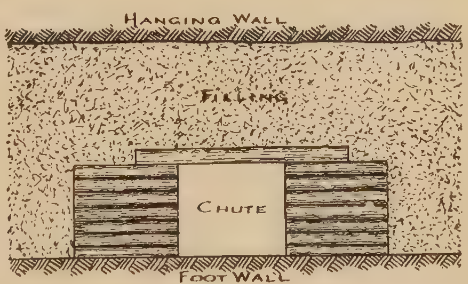


FIG. 261.—Using footwall as one side of ore-pass.

and the idea in using this type of chute is to make the wall itself serve as one side, and thus save the use of timber in a position where it is subjected to the most wear. This form of chute can only be adopted in circumstances where the footwall is exceptionally strong. It is formed by placing roundlogging end on to the chute space, bridging the hanging-wall side with poles, and surrounding the whole with waste rock. It may be readily understood that a chute of this kind would give a maximum of service, but a lot of timber is used in its construction, and in places where timber is scarce the cost might easily be prohibitive.

A variation on the type of pass last described is that shown in fig. 261A, commonly known as a Cornish ground-pass. It was much used in Cornwall, and was widely adopted on the Thames field in New Zealand. It was formed by placing across the opening, pairs of stout posts or stulls, spaced at 4 feet 6 inches apart, from centre to centre, in a more or less vertical position, the lower ends of the posts being hitched into the footwall and the upper ends kept apart by spiking a piece of strong plank across them close to the hanging-wall. In cases where the hanging-wall was liable to flake, a cap-piece was used, behind which laths could be entered as required. Planks or slabs were also spiked on the inner sides of the posts to form the ends of the pass. The footwall itself was used as one side of the pass, and the heaviest wear came on it.

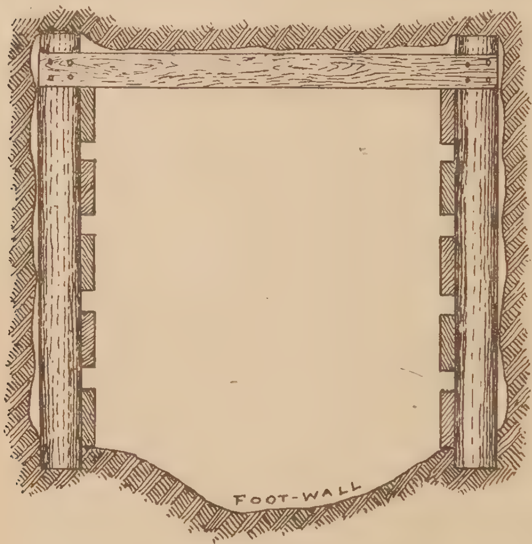


FIG. 261A.—Cross-section of Cornish ground-pass.

Passes of this kind are not suitable for lodes of a greater width than 8 feet, and can only be employed in ground of good standing nature. On the Thames field it was found that for their successful use the angle of inclination should not be less than 40° nor more than 65°. A manway could be formed in them, if desired, by putting a third stull in each set, and partitioning off one end. Occasionally the passes were made of three compartments, in which case the centre one was planked off as a travelling-way. Under favourable circumstances passes of this kind give good service.

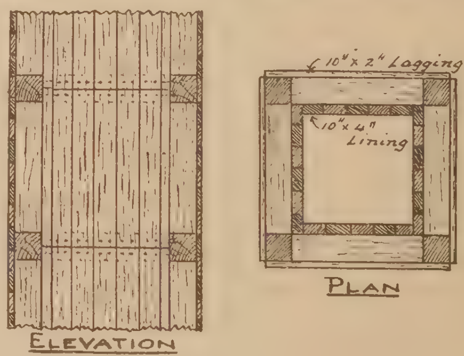


FIG. 262.—Ore-pass in square-set stope.

In mines with a large output the ore-chutes are usually put up separately from the manways, and many methods of timbering them are followed. In the square-set stopes of most of the Australian Broken Hill Mines, both the ladder-ways and ore-chutes are formed by paddocking-off a set here and there at convenient intervals, the respective passes being started from off-sets from the gangways. A manway, as a rule, is simply lined on the outside of the sets with sawn timber, usually 10 inches by 2 inches, or 10 inches by 3 inches Oregon, with the planks placed horizontally on their narrow edge. The rock-chutes are, however, also lined inside the set timber, as in fig. 262, with hardwood planks 4 inches thick. This inside planking is stood vertically,

and may be of lengths sufficient to cover one or two sets. It is spiked solidly to the caps and struts of the sets. The heavy galena ore of these mines exercises great cutting effect on the planks, but this form of hardwood lined ore-pass gives very reasonable service, and even though repairs are necessary from time to time, the work of replacing worn planks is readily and comparatively cheaply carried out.

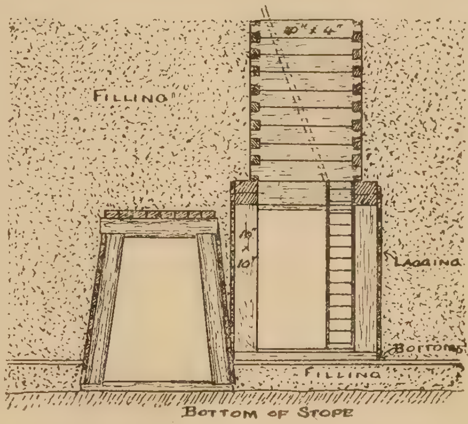


FIG. 263.—Manway in large open stope.

In other mines on the same field, where open stoping is the method of mining followed, both the manways and the ore-chutes are of the cribbed or *gwyndered* type. Fig. 263 represents a manway in the Broken Hill South Mine, as described by Fairweather (20), constructed in the manner mentioned. A square-set, 4 feet 4 inches on either side (inside measurement) and 8 feet high, is first stood, in an off-set from the main gangway, and on top of this the cribbing, 5 feet by 10 inches by 4 inches is built up, the timber being joggled at the ends to make a 2-inch opening between adjacent pieces. For ore-chute purposes, passes of this kind are lined inside with vertical planking in a similar way to the square-set ore-chute. Occasionally this inside lining is not spiked on until the chute has been in use for a short while, but it is advisable at all times to put it in from the start, as the falling ore rapidly cuts the crib timber away, and its replacement is difficult. Moreover, when inequalities appear on the face of the chute the lining is not so easily secured as would otherwise be the case.

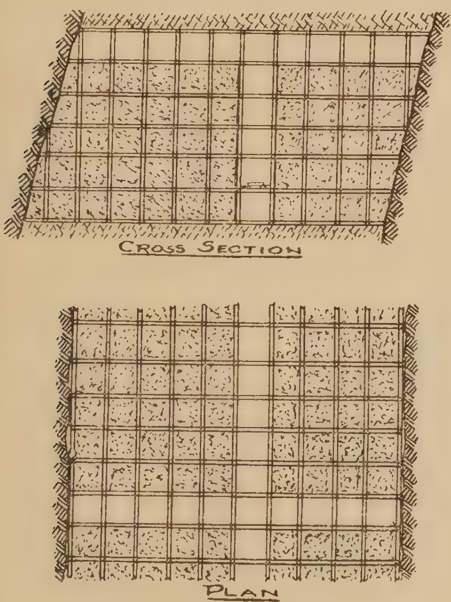


FIG. 264.—Arrangement of *chinamen* in square-set stope.

In some of the larger mines of the Chillagoe field in Queensland, it was once the custom in the square-set stopes not to bring up independent ore-passes such as have so far been dealt with in these pages, but to leave open spaces one-set wide running both longitudinally and transversely through the stope. These spaces were left, as shown in fig. 264, directly over the main gangways. The sets extending on either side to the walls were filled, but the broken ore was shovelled down into the open spaces, where it fell on *chinamen*, from which it was subsequently

dropped direct into trucks for removal. The writer has seen ore-passes (if they can be so called) of this kind carried up to considerable heights, without any serious injury resulting to either pass or stope, nevertheless this method of getting ore out of a stope is not to be commended, for the leaving of such large openings cannot be other than a source of danger in a wide lode. The breaking of one cap or strut, which may easily be caused by pressure from the filling or a fall of rock from the backs, may bring about the jackknifing of every set standing in the working, and this is a risk not to be faced lightly.

Further methods of timbering rock-chutes in square-set stopes are those shown in figs. 265 and 266. The first of these consists in laying in horizontally between the posts of the square-sets other timbers of the same cross-section

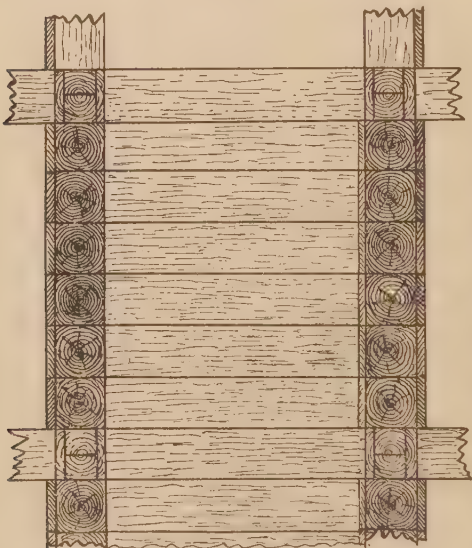


Fig. 265.—Another method of constructing ore-pass in square-sets.

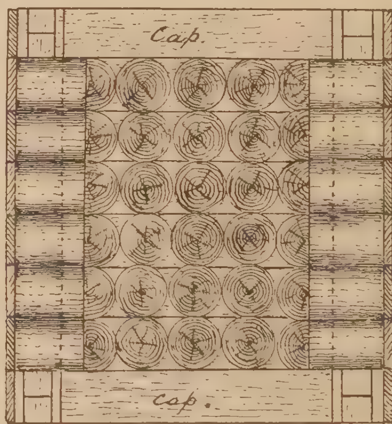


Fig. 266.—Method of *bricking* an ore-pass in square-sets.

as the posts and caps, each piece being tightly wedged in position. This has the effect of transforming the set into a crib. The chief disadvantage of this method is that in using it there is a certain amount of wear on the caps and struts by the dragging of the ore, and although this may not be great, it is best avoided. To prevent injury of this kind to the set-timber, the plan of lining the chute shown in fig. 266 has been tried. This consists of what is termed *bricking* the chute with blocks of either round or squared timber sufficiently long to project into the chute several inches beyond the face of the set-timber. In a chute *bricked* in this way, practically the whole of the wear is on the end of the blocks, and when these get worn away it is comparatively easy to remove and replace them. The blocks when put in must be tightly wedged.

In place of having continuous rows of blocks between the caps of the sets, alternate rows of the short *bricks* and of longer timber are used sometimes, in which case each of the latter is drift-nailed at its ends to the posts of the set.

CONSTRUCTION OF CYLINDRICAL WOODEN ORE-CHUTES.

The employment of cylindrical ore-chutes, constructed either of steel or timber, has been tried, and under certain conditions appears to have given

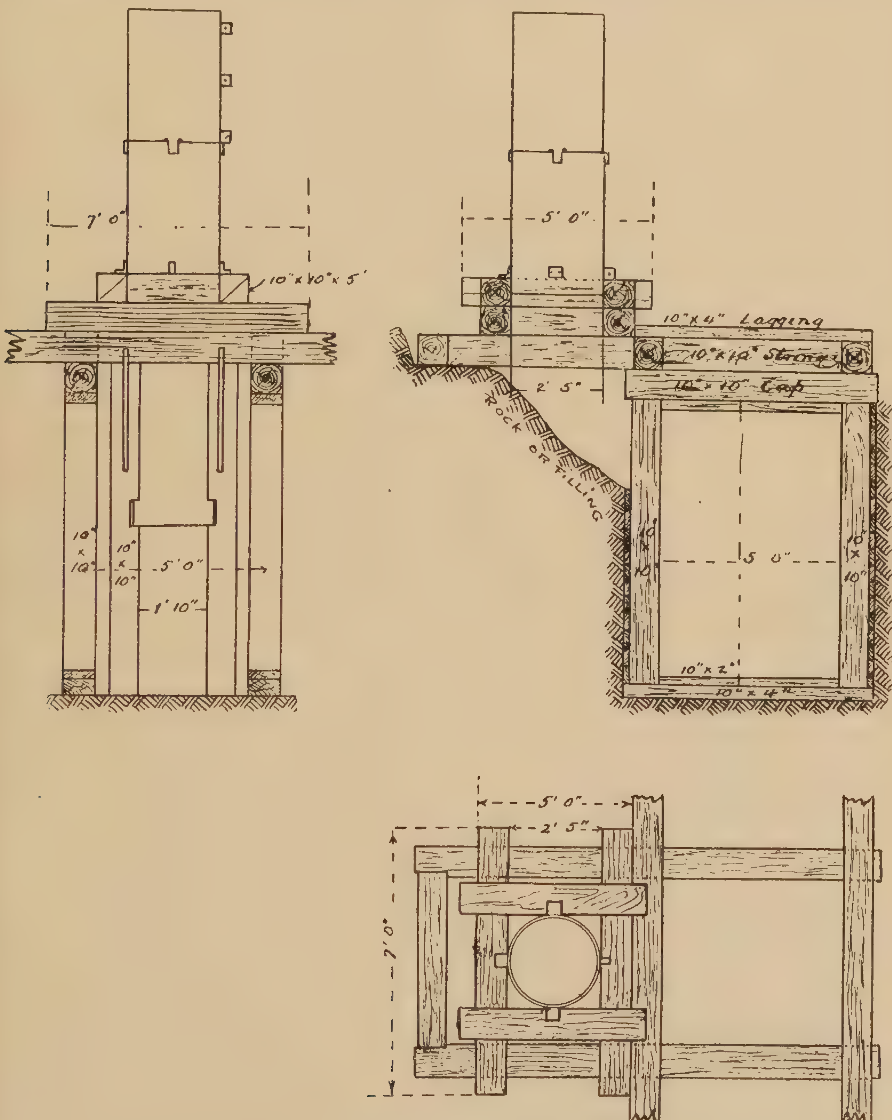


FIG. 267.—Timber foundation for cylindrical steel ore-chute.

satisfaction. In the erection of steel chutes of this type, very little timber is needed, and this only by way of providing a suitable foundation for the cylinder. Fig. 267, which is taken from a paper by Bridge (37), shows the way

in which this foundation was built up at the South Blocks Mine at Broken Hill, and will serve as a sufficient guide in carrying out any similar work.

Cylindrical wooden chutes, being made almost entirely of timber and presenting a number of unusual features, call for fuller description. Chutes

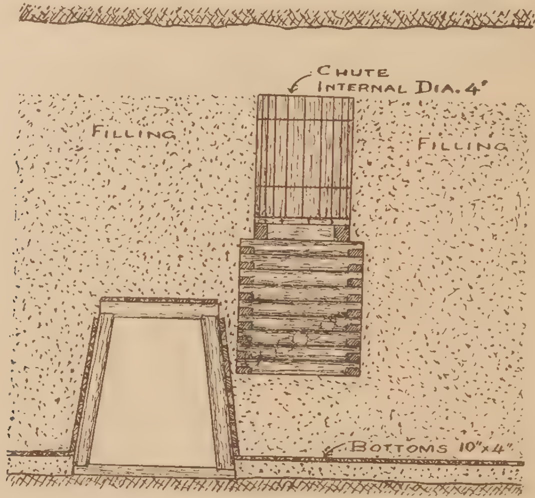


FIG. 268.—Starting cylindrical wooden ore-chute.

of this kind have been used since about 1907 in the South Broken Hill Mine, New South Wales. So much difficulty had been experienced in that mine in effectively maintaining other types of chute, such as the cribbed or the lined square-set, that experiments were made with the cylindrical wooden form,

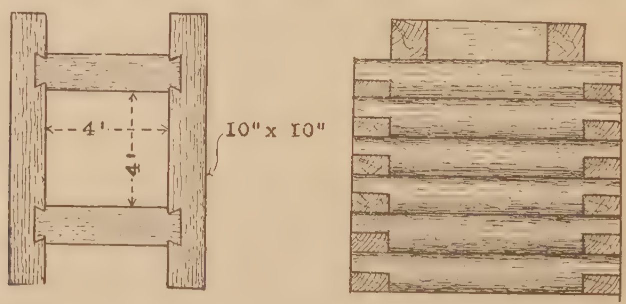


FIG. 269.—Base for cylindrical wooden ore-chute.

and the results proved so satisfactory that this type has ever since been adopted as a standard. A full description of its construction and use has been given by Fairweather (4), from whose paper figs. 268 to 279 have been taken, and the following description has been adapted.

In the open stopes the passes are started, as shown in fig. 268, by building up rings of round timber to a height of 13 feet above the floor of the level. On top of this cribbing a framed-set, consisting of four pieces of 10 inches by 10 inches Oregon pine, is placed. This set is prepared, as shown in fig. 269, by dovetailing two of the pieces into the others. On top of this framed set a

ring of what are called chute-blocks is placed. These are cut as shown in fig. 270 from 2-foot 4½-inch lengths of 10-inch by 4-inch stringybark timber. Eight of the blocks are required to form the complete ring, and when they are

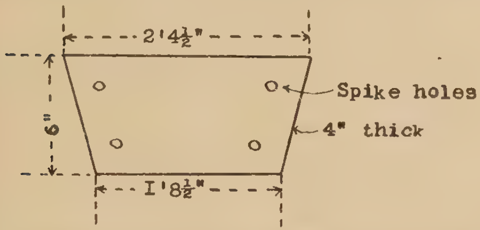


FIG. 270.—Chute-block for cylindrical ore-pass.

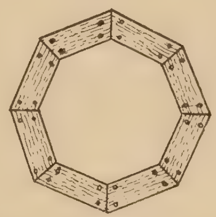


FIG. 271.—Ring of chute-blocks.

fitted together (fig. 271) they form a foundation for the 4-foot diameter chute barrel. Each block is spiked down with four spikes to the framed set.

Types of Cylindrical Wooden Ore-Chutes.—Four different types of chutes are used, the dimensions of which are as follows:

1.	Chute	10	inches thick,	4	feet internal	diameter.
2.	,,	10	,,	3	,,	,,
3.	,,	6	,,	3	,,	,,
4.	,,	5	,,	3	,,	,,

The length of the staves in all cases is 4 feet.

In actual practice it is not customary in the open stopes to carry a chute through from level to level in the one size, the diameter of the barrel being reduced from time to time as the stope ascends. In the square-set stopes Type 3 is used throughout, as the available space inside the set-timber does not admit of the use of a barrel of greater diameter than this. Type 4 is only used for repairing old cribbed passes that have failed. The conditions under which the various types are used are as follows:

Vertical passes: Open stopes.

Height of chute.	100-foot lift.	150-foot lift.
0 to 35 feet	Type 1	Type 1
35 feet to 70 feet . . .	Type 3	Type 2
70 feet to 120 feet . .	..	Type 3

Inclined passes: Open stopes.

Height of chute.	100-foot lift.	150-foot lift.
0 to 35 feet	Type 1	Type 1
35 feet to 70 feet . . .	Type 2 (modified)	Type 2
70 feet to 120 feet . .	..	Type 2 (modified)

The staves forming the barrel are cut either from round or squared timber of 10-inch by 5-inch, 10-inch by 6-inch, and 10-inch by 10-inch dimensions.

When green-squared stringy bark is used, the templates employed in marking off the staves for cutting are as shown in fig. 272. If the timber is well seasoned before cutting, sufficient shrinkage takes place to necessitate the use of an extra stave in forming the barrel, consequently templates as shown in fig. 273 have to be used. It will be seen that in the cutting of the 10-inch by

10-inch timber no waste results, but more or less is unavoidable when cutting the other sizes.

Method of Erecting Cylindrical Wooden Ore-Chutes—The procedure in erecting the chute is as follows: One 4-foot piece is stood on end, with its inside face flush with the inside of the chute-block frame. One timberman holds it in place, while the other man gets a second piece. This is stood against the first, and the two are secured one to another by driving in a small timber-dog, as shown in fig. 274. Both men then take a side each, standing the staves,

4-foot chute, 10 inches thick, 37 pieces to section.

3-foot chute, 10 inches thick, 29 pieces to section.

3-foot chute, 6 inches thick, 15 pieces to section.

3-foot chute, 5 inches thick, 15 pieces to section.

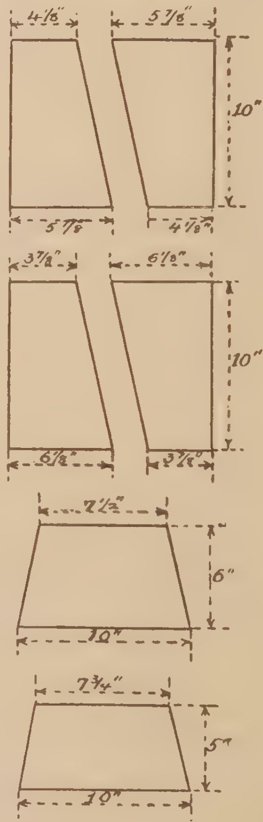


FIG. 272.—Templates for marking off staves.

and working towards one another, each fresh stave being secured by a timber-dog, and the chute blocks serving to give the approximate location of the staves.

When the ring has been completed, two lengths of fencing wire are cut, each length being a little more than twice the outside circumference. The wire is put twice round the barrel, at a point 12 inches from the top and a similar distance from the bottom, and the ends are connected by tying. A fair amount of slack is allowed to permit of this tying being done. A hole $\frac{3}{4}$ inch diameter and 2 inches deep is bored in any stave 12 inches from the top, and another 12 inches from the bottom, into each of which a short piece of $\frac{3}{4}$-inch iron is driven, projecting about 3 inches. The slack of the wires is caught up by a short drill and twisted around these pins. When both wires

4-foot chute, 10 inches thick, 38 pieces to section.

3-foot chute, 10 inches thick, 30 pieces to section.

3-foot chute, 6 inches thick, 15 pieces to section.

3-foot chute, 5 inches thick, 15 pieces to section.

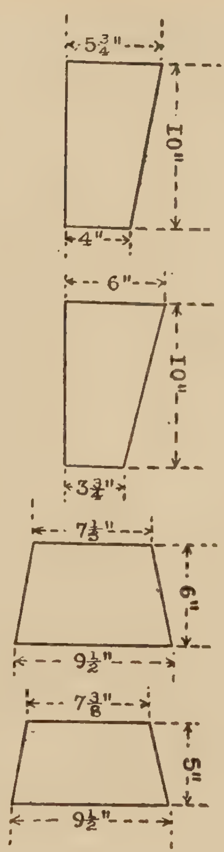


FIG. 273.—Templates for marking off staves.

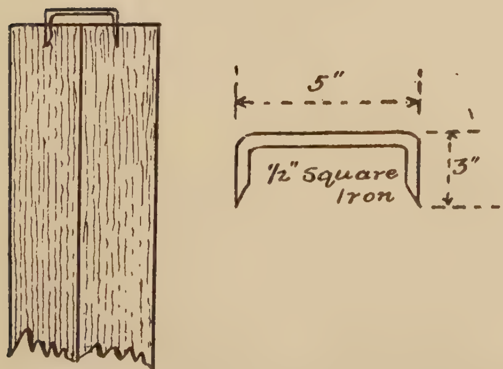


FIG. 274.—Showing use of iron dogs to hold staves while barrel is being erected.

have been tightened fairly well, the chute-dogs are withdrawn, and one timberman then goes round the chute hitting the staves with the back of his axe, while the other man puts the final strain on the wires by twisting.

When the timbers have been closed up tight, the end loops of the wires are fixed in position by spikes driven into the staves. This prevents possible slackening.

When the first section is finished, the second one is built on top in the same way, the lower barrel serving as a guide for the construction of the upper one.

With all the staves being the same length, the surface at the top is flat. This lack of connection between two adjacent sections was thought at first to be a weak feature, but experience has shown that when the chute has been enclosed with filling there is no tendency to lateral movement.

When two lengths of barrel have been stood, an 8-foot or 9-foot layer of filling is run in, and spread evenly around the chute, particular care being taken to see that it does not pile up on one side only. This care is most needed with the thinner and lighter sections of barrel; with the chute consisting of 10-inch timber an advancing rill does not seem to have any effect in tilting. If by accident it is altered in inclination, the chute is put right again, in a

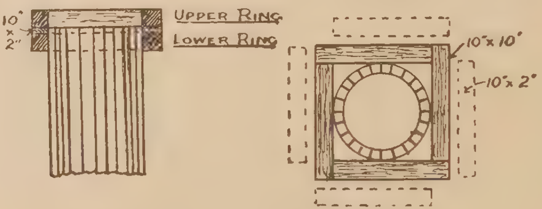


Fig. 275.—Protecting top of chute.

simple case, by relieving the pressure and giving a few blows with the hammer; in a serious case by taking apart and building up again.

As a rule, when the filling is completed, the tops of the chutes are buried about 12 inches. This is an advisable arrangement, as the stave ends are thus protected from the effects of firing in the stope. Should a big fall of ground take place, the sudden pressure is better distributed around the chute. As a further protection to the top section in stopes where the ore is liable to break large, two rings of bulk timber are placed around the top of the staves, as in fig. 275, the bottom ring flush with the top of the barrel, and the upper flush with the surface of the filling. At one time these rings were bound together with iron bolts, but experience showed that this provision was not necessary, and the use of the bolts was abandoned. The 10-inch by 10-inch timbers in the rings are tied together with 10-inch by 2-inch planks, spiked on in the opposite direction.

As previously indicated, the chutes are reduced at 35 feet, and again at 70 feet. In each case the reduction is effected by placing a frame-set similar to that shown in fig. 269, only of smaller dimensions, on top of the barrel, and arranging on it another row of chute-blocks on which the section of smaller chute is erected.

Inclined Cylindrical Wooden Ore-Chutes.—In the mine referred to the wooden cylinder is used as an inclined chute as well as in a vertical position, but owing to the wear that must inevitably fall on the lower part of a chute of this kind, a different arrangement in setting up the barrel has to be adopted. This consists in inserting between each of the staves on the underside of the

chute, mild steel plates $\frac{1}{4}$ inch thick and 9 inches deep, as shown in fig. 276. These plates are held in place by dowels which pass through holes bored near the outer edge of the plates, and enter the staves, two pins of $\frac{5}{8}$-inch round iron being used with each plate. The action of the ore is to cut a trough about 1 inch deep between adjacent plates, after which the plates themselves take

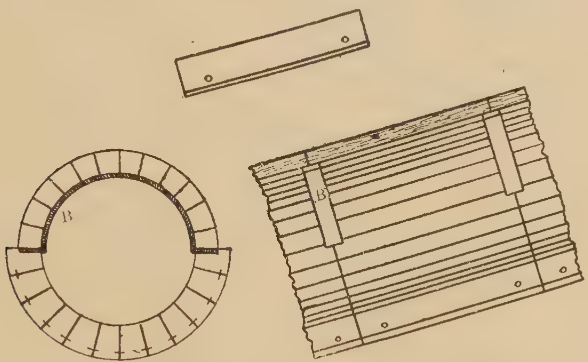


Fig. 276.—Construction of inclined cylindrical wooden ore-chute.

practically all the wear, and thus protect the timber. Staves of different sizes are also used in the upper and lower sides of the chute respectively, 6-inch staves being employed in the former and 10-inch in the latter. No plates are inserted between the 6-inch staves, but they rest on arch-bars, as shown in fig. 276 at BB. These bars are of iron, 4 inches wide and $\frac{5}{8}$ inch thick, bent to a curve of slightly less than 18 inches radius, and provided with lugs 6 inches long. They are placed under the lines of contact of adjacent barrels, and to provide a seating for the lugs, recesses 6 inches by 4 inches by $\frac{3}{4}$ inch deep are chiselled out of the top staves of the lower part of the chute before the upper half is put in place. The bars serve the double purpose of acting as a support for the upper timber while the chute is being constructed, and protecting the chute against possible collapse in case of a heavy fall of ore from the backs. This kind of chute is the one previously referred to as Type 2 (modified).

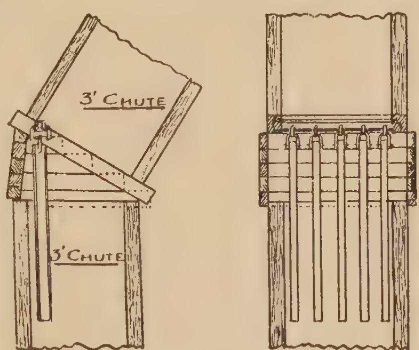


Fig. 277.—Arrangement of timbers at bend in cylindrical wooden ore-chute.

Changing Cylindrical Ore-Chute from Vertical to Inclined.—These cylindrical chutes may be changed from vertical to inclined, the way in which it is done being shown in fig. 277. The inclined part of the chute is built up on a framed set such as previously described, 3 feet square within, which is blocked up on one side by 10-inch by 10-inch timbers. The openings at the sides, between the framed set and the top of the vertical barrel, are closed by 10-inch by 2-inch laths, spiked to the framed set and the blocking. Across the framed set, and parallel to the 10-inch by 10-inch blocks, a piece of 40 lb. rail, 3 feet 10 inches long, is placed, with its ends resting in recesses 5 inches deep

cut in the framed set. In the rail, five holes are drilled, 1 inch in diameter, and $6\frac{1}{2}$ inches apart, from which further pieces of rail are hung by means of $\frac{7}{8}$-inch shackles. The purpose of these rails is to protect the timber of the lower chute from *beat*, the ore, falling down the inclined chute, striking against them.

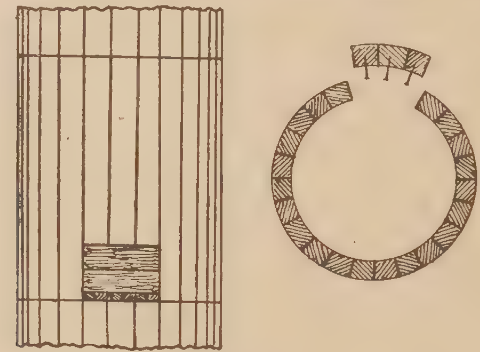


FIG. 278.—Renewing worn staves in cylindrical wooden ore-chute.

Fixed grids were tried with the same object in view, but it was found impossible to maintain them in place.

Repairing Cylindrical Wooden Ore-Chutes.—Practically the only repair work found necessary with these cylindrical chutes is that of renewing staves that have been cut out in vertical barrels. It may be that only a few staves need

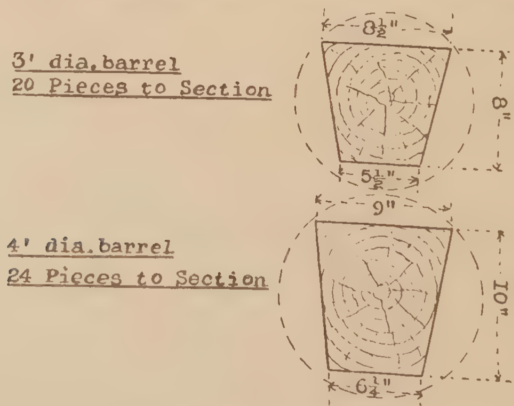


FIG. 279.—Preparing chute staves from round timber.

removing at any one time, but occasionally the whole barrel has to be replaced. When it is only a matter of renewing two or three staves, the method followed is as shown in fig. 278. The worn staves are cut away and the filling behind them is cleaned out sufficiently to admit of the new ones being stood inside, and clear of the chute barrel. These new staves are cut 10 inches shorter than the usual stave length, and each has a spike driven into it near the top and another near the bottom. By pulling on these, the staves are drawn into their place, any tightening that may be necessary being done by striking them on the outside with a hammer, the timberman putting his arm through the 10-inch space at the bottom to do this. When the closing up is completed, any

space behind the staves is filled with sand, which is rammed as well as circumstances permit. The 10-inch opening in the staves is then filled by placing in it two chute-blocks cut to size, over which wedges are driven. To form a backing for the chute-blocks, old timber is packed in tightly behind them before they are put in place.

In case a whole barrel of the chute has collapsed, the old staves are removed and replaced by new ones of full length, as little filling as possible being taken out in the process. When all the staves are in except two or three, the same procedure is followed as in the case when only partial renewal of the barrel is necessary, the filling being cleared back, and short staves used as described. As a rule, the old stope filling is found to stand up well enough to enable the damaged barrel to be taken out and renewed in the manner stated without any serious runs. When several adjoining sections of barrel have to be renewed, work is started on the lowest, in which case full length staves are used in all the sections except the closing one, the final stave in each of the lower sections being dropped into place from above.

Round timber is not much used for staves, and then only for the larger sizes. The method of preparing these is shown in fig. 279.

CHAPTER XI.

CONSTRUCTION OF CHUTE-GATES OR DOORS.

In the following notes on the various ways of building gates or doors for controlling the discharge of material from passes or underground ore-pockets, description has been limited to types in fairly general use, and only those have been dealt with in the construction of which timber is largely, if not entirely, employed.

Whatever may be the kind of gate used, a certain amount of skill is called for in putting it together properly. In many mines, the face-men are themselves expected to rear the passes in the stopes, but in all except the very smallest the work of building the chute-gates is entrusted only to men specially experienced in carrying it out.

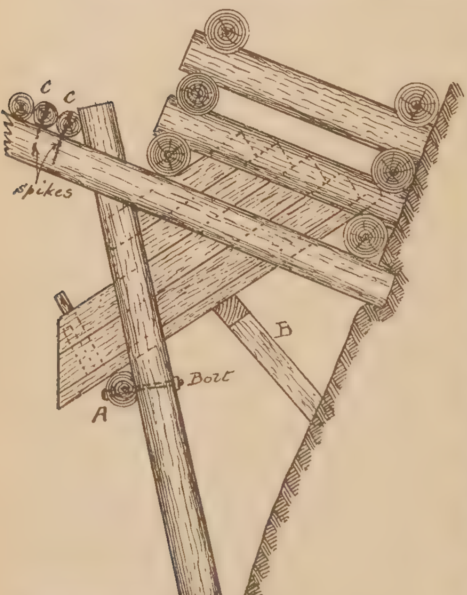


Fig. 280.—Wooden chute-gate for small mine.

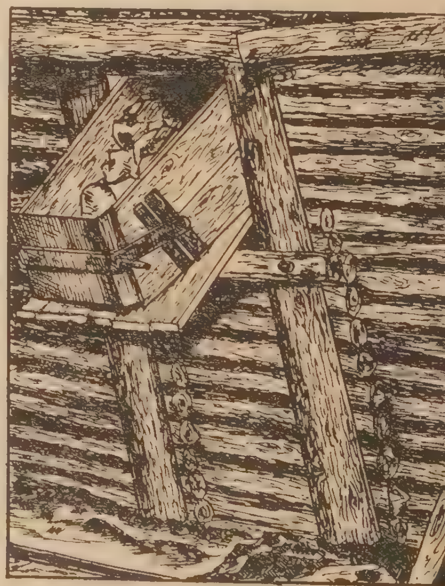


Fig. 281.—Simply constructed chute-gate for small mine.

As a rule, the practice is to put in the gate as soon as the pass has been carried up to the height of one stope, and the first operation is to lay the floor. On this part the wear is very severe, and it is necessary that whatever timber is

used should be of the toughest quality procurable. In wide lodes worked on the open-stoping method the plan is sometimes adopted of forming the floor by standing short wood blocks on end, as shown in fig. 287, bedding them on the filling. Floors of this kind give long service. The more general custom is to make the floor of stout planking laid at an inclination of about 40 degrees towards the trucking road. The upper ends of the planks are usually secured by being spiked either to the wall-plate of the bottom regular pass-set, as in fig. 280, or to a bearer put in for the purpose, as in fig. 283. If the ground immediately under the floor is solid, this upper end of the planking is, at times, merely laid on it, while if the pass is in square sets it may be either secured to the cap or strut of the sill-set or to a bearer placed across the set, as in fig. 292.

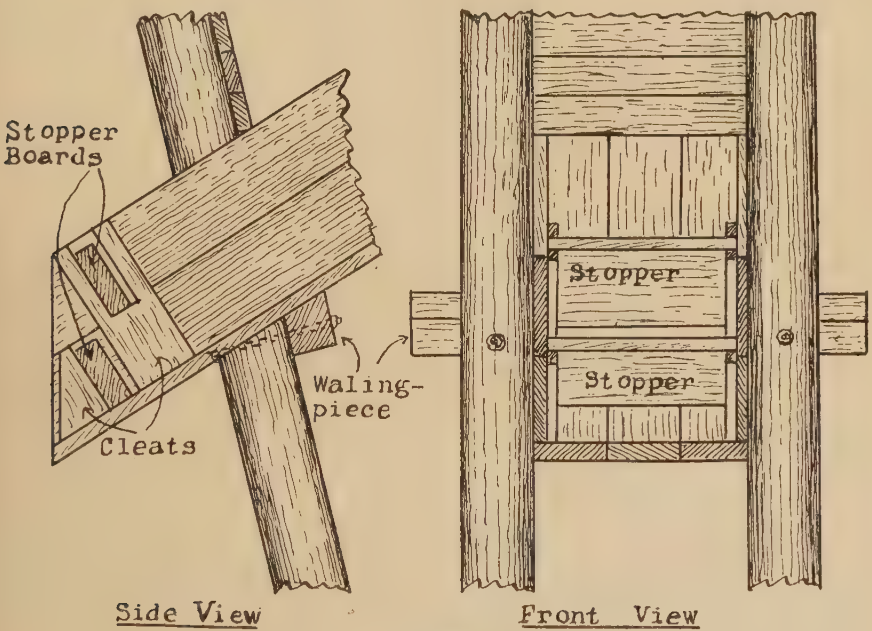


FIG. 282.—Timber chute-gate.

Towards the lower end, the planks are spiked to a waling-piece, which may be inserted either between the legs of the two level sets, as shown in figs. 285 and 292, or bolted in front of or behind them, as in figs. 282 and 281 respectively. If the waling-piece is placed in the first-mentioned way, a housing needs to be cut well into the leg of the level-set on either side to secure it effectively, and if in the latter way it must be firmly bolted to the legs. Precautions of this kind are necessary by reason of the fact that the weight of ore in a pass exerts great pressure against the piece, and if not well secured it is only too likely to be crushed down. When the waling-piece is inserted in housings in the legs, additional support is sometimes given it by nailing lengths of 8-inch by 2-inch or 8-inch by 3-inch timber to the sides of the legs immediately under it. If the space between the waling-piece and the rear end support of the floor is fairly long, it may also be advisable to provide a central support for the floor planks, as shown at B (fig. 280). The timber used in the flooring is usually 3 inches or 4 inches thick, and of the toughest variety procurable.

The waling-piece has to be put in place before the flooring is laid. If the chute is in a square-set, this work offers no difficulty, owing to the regularity of the timbering, but under other conditions a good deal of care has to be exercised to see that it is put in at the correct height. In a small lode the timbering of no two passes or chutes is started in exactly the same way, and the distance between the footwall of the pass and the outside of the legs of the level-sets varies considerably. This means that if one stereotyped way of securing the upper ends of the flooring and placing the waling-piece is followed, the floors of the chutes would be at a variety of angles. What the timberman has to look out for is that when the floor is laid the outer ends of the boards will not be too high to make loading from the chute awkward, nor so low as to catch against passing trucks. The correct height of the outer edge should be about three clear inches above the tops of the trucks used on the road, and it should project about six inches over the near side of the truck. To ensure that

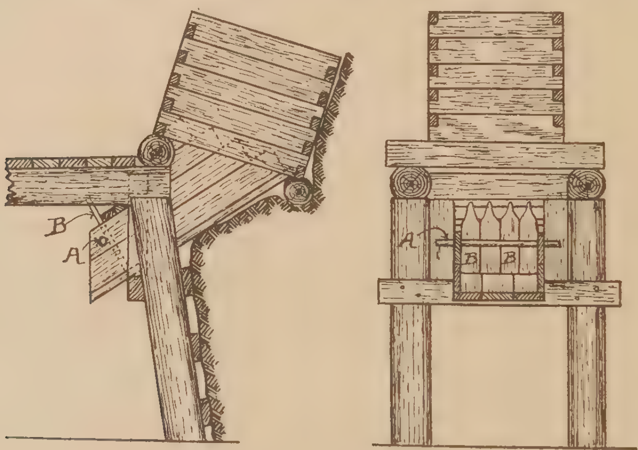


FIG. 283.—Timber chute-gate.

these conditions are met, the timberman has to measure carefully the correct height required for the waling-piece before this is secured in position. A common way of doing this is to stand a truck in the place it would occupy when being filled from the chute, and, using it as a guide, mark off by the use of straightedges the height required.

When the floor has been laid the sides are put in. These are generally of 2-inch timber. At their upper ends the boards are spiked to the inside of the side-plates of the bottom set of the pass, and at their lower ends either to the legs of the level-sets or to uprights stood inside them and secured to the waling-piece. For the small trucks used in many mines it is not advisable to have the opening of the gate more than about 3 feet wide. In square-sets, where the distance between the legs of adjacent sets may be as much as 5 feet, it is customary, for this reason, to close the gate in towards its lip by means of the uprights referred to.

If the gate is to be a simple one, say of the type shown in fig. 282, the projecting ends of the floor and side-boards are usually not sawn off till all are in place, when the correct length at which they are to be cut is determined by running a truck under the lip. When the timbers are not intended to project, they are cut off flush with the outer sides of the level-set legs. One or two

boards are next nailed across the outer side of the level-set legs to close the chute opening above the side timbers of the gate, should such provision be necessary, when all that is required to complete the gate is to equip it with the necessary stoppers or iron door, as the case may be.

The general arrangement of a chute-gate in a level that has been timbered with stulls is shown in fig. 280. Several stout poles are laid across the stulls between which the pass is situated, and spiked down as at CC, and against

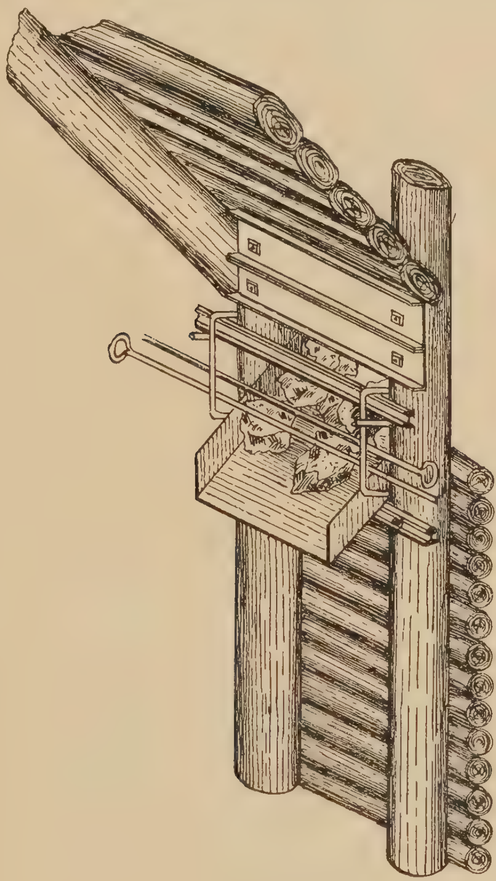


FIG. 284.—Chute-gate for rough ore.

these, two uprights are stood, to which the waling-piece A is bolted. The timbers forming the bottom and sides are then placed in the usual way. Short horizontal stopper-boards, which rest behind cleats nailed to the inner side of the side timbers of the gate, are used to regulate the flow of material from the pass. Fig. 281 shows a simple form of chute-gate suitable for small mines in which the levels are formed by three-piece or four-piece sets. The actual framing of the chute is carried out in similar manner to that of the chute just described, but instead of stopper-boards an iron door is used. This door lifts upward with a circular movement, and is provided with short handles on either side to enable it to be operated without danger to the truckers.

Of chute-gates made wholly of timber, the two types shown in figs. 282 and 283 are in very common use. In the first of these, two stopper-boards, placed

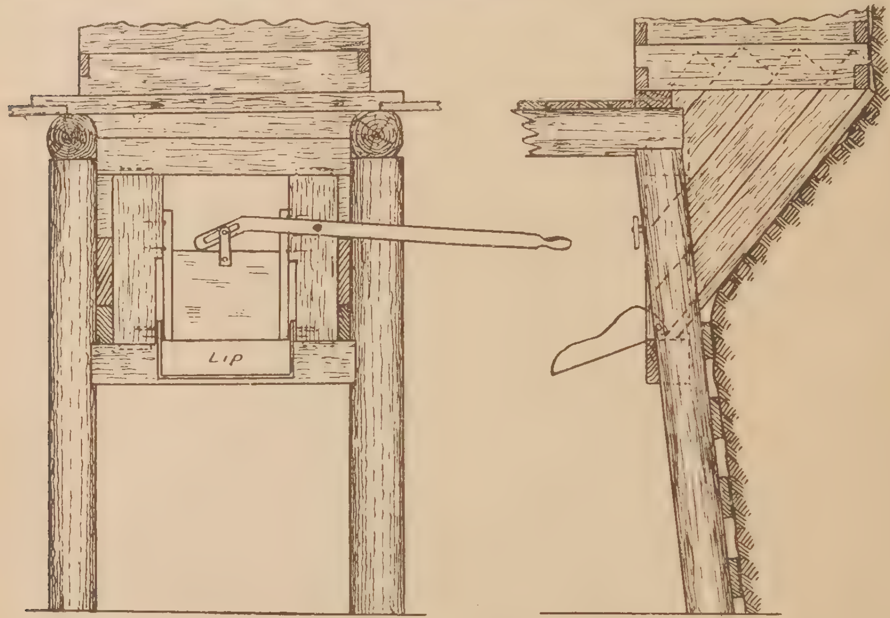


FIG. 285.—Chute-gate for horse-road.

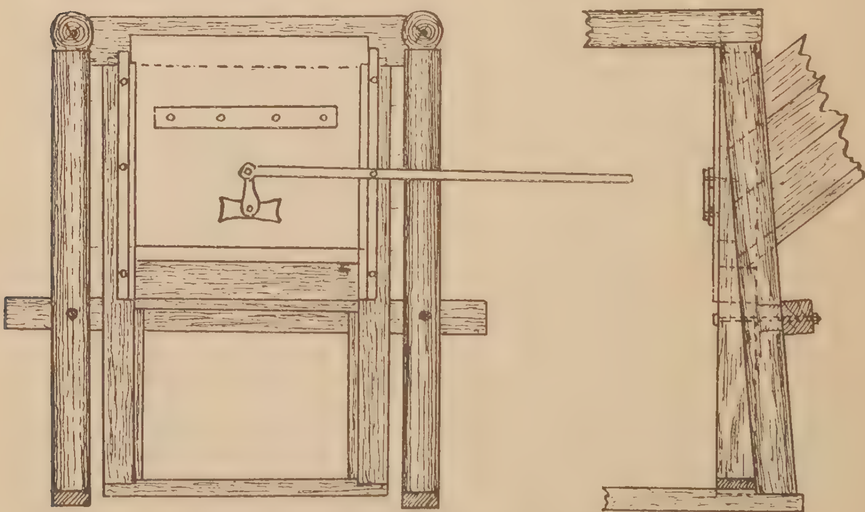


FIG. 286.—Chute-gate for horse-road.

horizontally across the chute, are held in position by cleats. The uppermost stopper-board is not allowed to slip down to more than half the depth of the chute-opening. When a chute of this kind is being drawn from, it is, as a rule, only necessary to raise the lower stopper-board to enable a truck to be filled

readily, but in case oversized rock finds its way into the chute the top stopper can be raised to admit of removal of the obstruction. Using the two stopper-

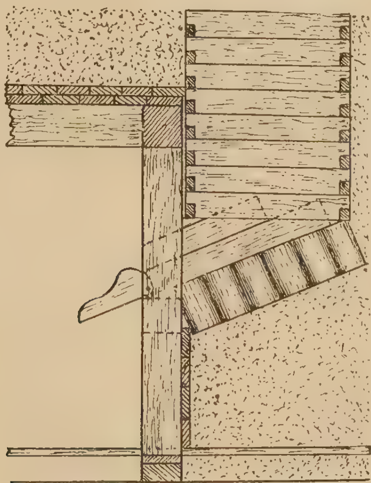


FIG. 287.—Chute with *bricked* floor.

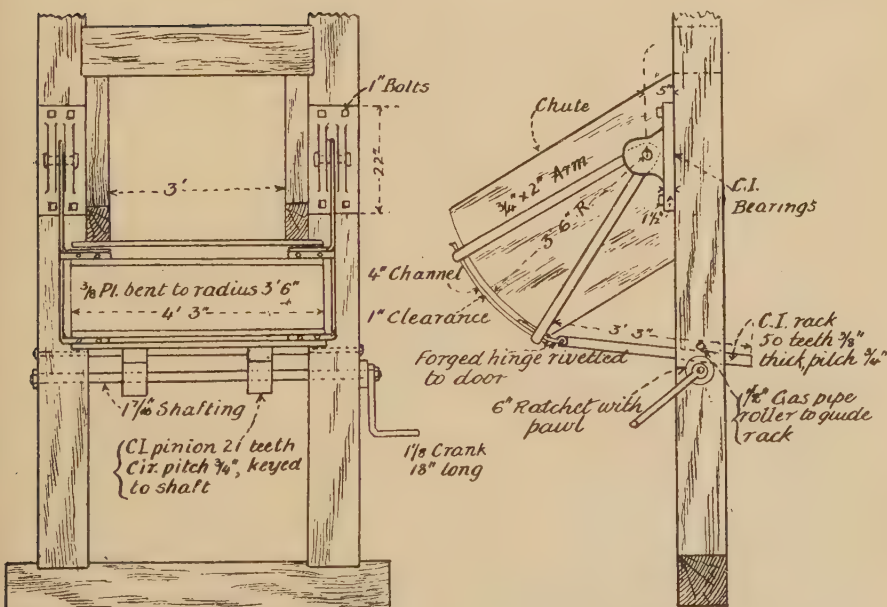


FIG. 288.—Chute-gate operated by rack and pinion.

boards in this way greatly lessens the danger of the truckers having their fingers caught by falling stone when opening or closing the gate. In the second type, a hole is bored through the side-board on either side of the chute, through which a bar of 1-inch or $1\frac{1}{8}$-inch round iron is inserted. Behind this bar a

sufficient number of short stopper-boards are stood vertically, and to prevent these being forced outward at their lower ends, their upper ends rest against other boards nailed across the top of the side-boards of the chute, as shown at B in fig. 283. When a chute-gate of this kind has to be operated, there is at times some little difficulty experienced in raising the vertical stoppers owing to the pressure of the material behind them, but they are easily prized up by using a small pinch-bar which is usually kept handy for the purpose. This type of gate gives good service. It has this advantage, that when the pass is steep and contains very fine and dry ore, only a small space need be opened at any one time, and, consequently, any sudden rush of the material can be very easily checked.

Fig. 284 represents a type of chute-gate described by Cleland (1) as being used in Western Australian mines for handling rough ore. In this case, while the

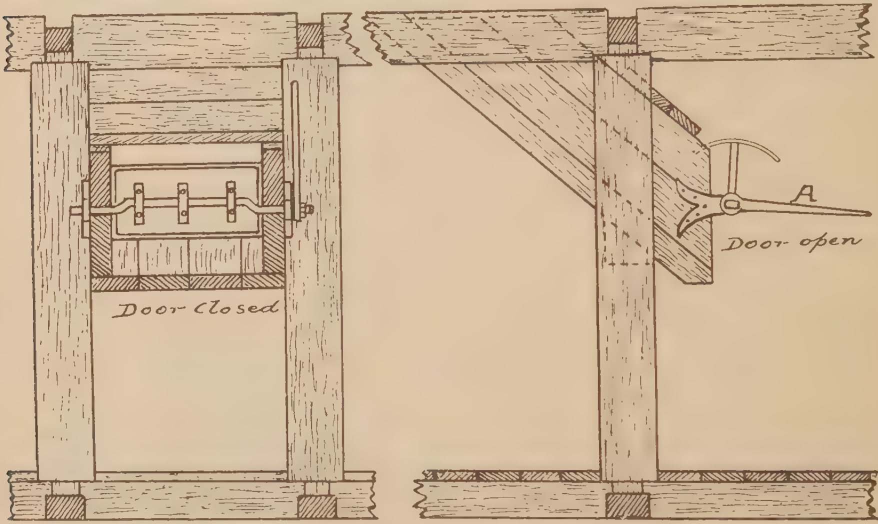


FIG. 289.—Quarter-pan type metal chute-gate, lever-operated.

inner portion of the chute is constructed in the usual way with timber floor and sides, the lip itself is of steel, and chute-bars or short lengths of light tram-rail are used as stoppers. With gates of this kind, however, it is frequently difficult to regulate the flow of material as well as could be desired, with the result that there is much slopping of ore over the sides of the trucks on to the roadway. They can only be used when the ore handled through them is all rough and fairly uniform in size, a condition seldom met with in actual work. One advantage the chute possesses is that extra large pieces of ore can be broken up at the lip either with a hammer or by blasting with explosives, without serious injury to the chute.

The chute-gate shown in fig. 285 is suitable for a level in which horses are used to draw rakes of trucks, or which has for any other reason to be kept free from obstruction. It may be readily understood that in a roadway where horses or electric tractors are used, chutes in which the lips project permanently into the level would be a great obstruction. In such circumstances the chutes are provided therefore with steel lips such as shown in the illustration, which can be lifted up out of the way when the chute is not in use. The lip is pivoted on either side on a coach-screw or bolt, and slots are provided in the framing of the

gate to admit of the curved sides of the lip entering. The door is usually of $\frac{3}{8}$-inch steel, and is raised or lowered by means of a lever. It travels up and down behind small angle-irons, and to prevent it being thrust out of place, strips of flat iron or steel are secured inside it, being generally held by the same screws or bolts that fasten the angle-irons to the uprights.

Fig. 286 is a gate of somewhat similar construction. It is fitted with a fixed steel lip (not shown in the illustration), but may be readily adapted to admit of a movable lip being fitted to it. It will be noted that the steel door

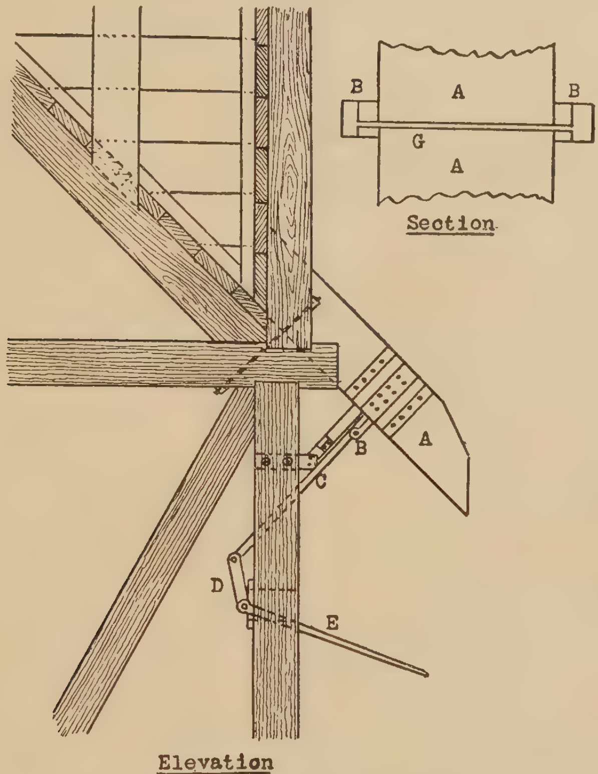


FIG. 290.—Chute-gate for rapid loading.

has been strengthened by having a narrow strip of steel-plate riveted across it. With metal doors of this kind some such reinforcement is very necessary, for the ordinary door plate is easily bulged by heavy ore falling on it, and when this happens it is difficult to raise or lower it.

The chute-gate shown in fig. 288 possesses some unusual features. Gates of this kind have been described by Hodge (38) as being used at the Burra Burra Mine of the Tennessee Copper Company, U.S.A. They are operated by means of two racks fastened by pins to lugs riveted to the lower edge of the door. These racks are placed with the teeth down, so that they are protected from dirt. No lubricant is used. Each of the racks works on a pinion keyed to a shaft which lies back and under the chute and turns in gas-pipe bearings set in the timber. A crank operates the shafting and pinions, one revolution raising or lowering the gate 6 inches, and effectually checking any rush of ore. Any

rock caught on the closing edge of the door, instead of clogging it, is thrown back into the chute by the rising door or pushed into the truck.

The type of gate shown in fig. 289 is also of steel, but its action is direct from a lever through a crank. When the gate is closed, the lever is in a vertical position, but is pulled down into the position shown at A when the gate is opened. The gate is easily constructed and controlled.

The gate shown in fig. 290 has been described by Del Mar (60) as being in his estimation one of the best gates for ore-bin chutes. "The sliding gate," he says, "operates from below by a lever, and slides up and down on wheels in a recess in the side of the ore chamber, but in such a way that the ore cannot get into these recesses. A boy can operate it, and can load cars as fast as they can be run under the lip of the chute. When loading must be done expedi-

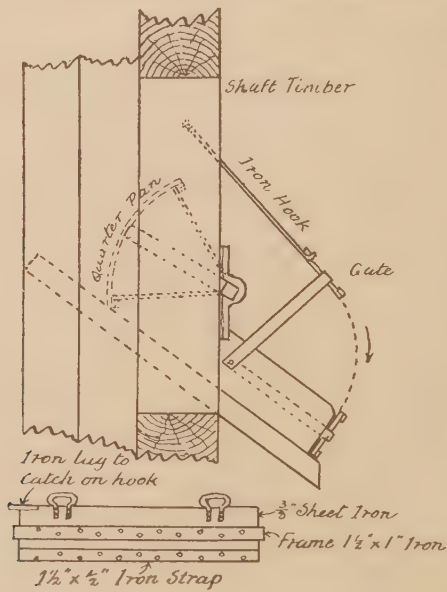


Fig. 291.—Emergency ore-gate.

tiously, for instance when a train of cars must be loaded, I believe they could be loaded by the use of this gate while in motion. The amount of ore going through the chute is that sliding over the top when the gate is let down and nothing can choke the return of the gate to the position where it cuts off the stream of ore. Referring to the elevation, A is a steel chute, B a sliding gate actuated by the levers C, D, and E. By lifting the lever E the gate is lowered, allowing the ore to run over the top of it. As the top of the gate can be lowered until it is flush with the bottom of the chute there is clear passage. When it is desired to shut off the stream of ore the lever E is depressed, throwing the gate up. Referring to the plan, A is the ore-chute, G is the slot in the bottom thereof through which the gate moves in a vertical direction, BB are the recesses or chambers in which the wheels which are attached to the sides of the gate slide up and down, so that the movement of the gate takes little effort."

Fig. 291 shows an emergency ore-gate mentioned by Davenport (35) as being used in one important mining district in the United States of America, in addition to the ordinary arc or quarter-pan gate, in order to minimise

difficulty that was experienced in cutting off the flow of fine ore. Hard lumps of ore would catch under the curved gate, and the fine ore continued to run. The emergency gate consists, as shown, of a $\frac{3}{8}$-inch iron plate, 8 inches wide, and long enough to cover the outer end of the chute lip, which is supported in such a way that it can be instantly dropped over the end of the chute.

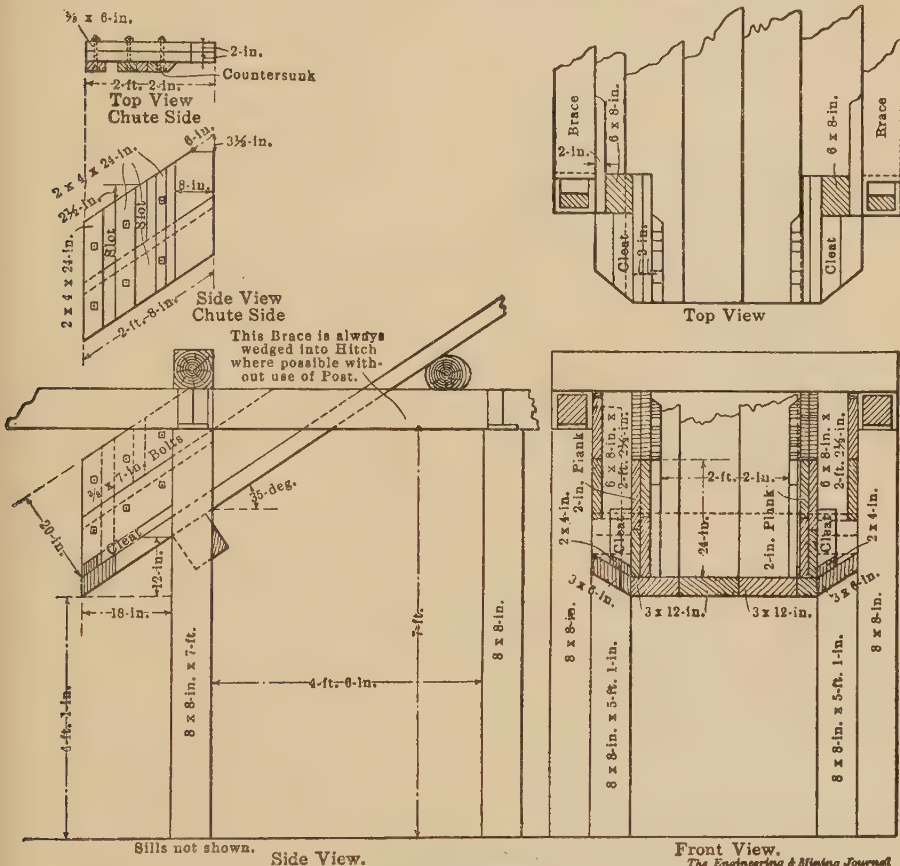


FIG. 292.—Standard ore-chute, Douglas-Nevada Mine, Nevada, U.S.A.

The chute and gate shown in fig. 292 is the standard type in use at the Nevada Douglas Copper Company's Mines, Nevada, U.S.A. It has been described by Arentz (17), from whose paper the illustration has been taken. At these mines all the chutes are constructed of the same sized timbers, all of the pieces being framed at the surface and sent underground ready to be put together. The construction is clearly shown, and does not differ very greatly from that of the chute shown in fig. 282.

CHAPTER XII.

TIMBERING ALLUVIAL WORKINGS.

THE different methods of timbering shafts, drives, rises, etc., in alluvial ground have been dealt with in previous chapters, and need not be referred to again in any detailed way under this heading. Apart from them, the only other timbering methods peculiar to the working of alluvial deposits are those followed in supporting the backs during blocking-out operations, and as these have not previously been touched upon some brief description of them will not be out of place.

The working of alluvial ground by underground mining methods is carried out in a different manner to that observed in lode mines. The layers of gravels containing values of sufficient importance to warrant them being exploited in this way are usually found in ancient stream-beds which in the course of time have been buried often to great depths below the present land surface. Sometimes the values in them are confined to leads only a few feet wide, at others they occur in beds many chains in width; frequently they are found only on the bed-rock, but in many instances they lie upon a false bottom or a series of false bottoms. In some places, the value-bearing drift can only be reached by means of shafts, and by driving on or under the lead; at others, millions of ounces of tin and gold have been won from it merely by means of tunnels from surface. In whichever of these varied ways, however, the drift occurs, the working of it is carried out in much the same manner as that of a coal seam, that is, on the one more or less horizontal plane.

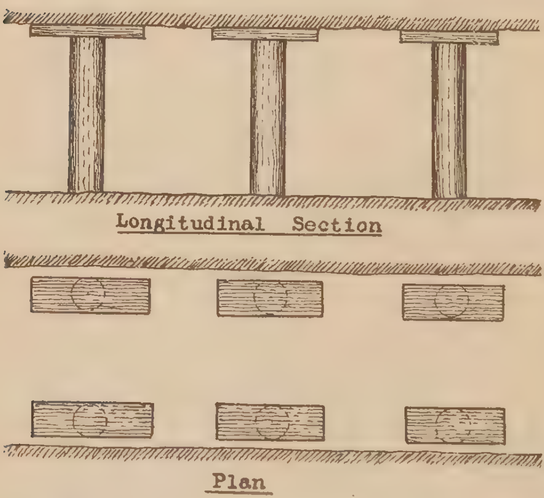


FIG. 293.—Timbering alluvial ground with props and breasting-caps.

If the layer of pay-dirt is in a terrace and can be worked from an adit, very little timbering of any kind may be required. In such cases the ground is generally dry and sufficiently compacted to be practically self-supporting. As a rule, however, it is advisable, if not actually necessary, to do a certain

amount of timbering, if it only consists in standing at intervals posts with breasting-caps, as shown in fig. 293.

The usual practice when opening out an alluvial lead is first to run in a main drive as nearly as practicable along its central line, but if the lead is very wide several drives may be advanced more or less parallel to one another. If the drive is in comparatively dry ground, as it usually is in the extensive terrace workings on the West Coast of New Zealand, it may not be necessary to stand any timber during the actual driving, but as blocking-out is started, posts with breasting-caps are stood on either side at suitable intervals. The breasting-caps, after being placed on the posts, are wedged tightly to the ground. In beginning blocking-out operations, crosscuts are run out from the main drift towards the lateral limits of the pay-ground, as in fig. 294. The whole of the gravel broken out in doing this work has to be trucked out of the working. A start is then made to block out by taking off slices as at AA. As the removal of these progresses, posts and caps are stood as shown. All the gravel from this first slice will also have to be taken to surface. A second slice BB is then broken out, and a second row of posts stood, as shown in fig. 295. On this occasion all the large stone from the slice and any valueless upper portion is thrown back into slice A, the stone being neatly walled up on the faces of permanent openings. In this manner the work goes forward, all the large stones being placed in the previously worked-out part and packed well up to the back, thus giving the latter a broad and firm support, and at the same time reducing the amount of ground to be trucked out to the fine material containing the values. In the case of a wide deposit where several drives are put in, the same plan can be followed, crosscuts being run from drive to drive and the blocking-out started from them. For ventilating purposes it may be necessary from time to time to put up a jump-up to surface—if the depth of the deposit will admit of it—otherwise the crosscuts mentioned will serve a useful purpose in providing a return air course to the shaft or adit. Jumps-up may be timbered in any of the various ways described in the pages dealing with rises and ore-passes.

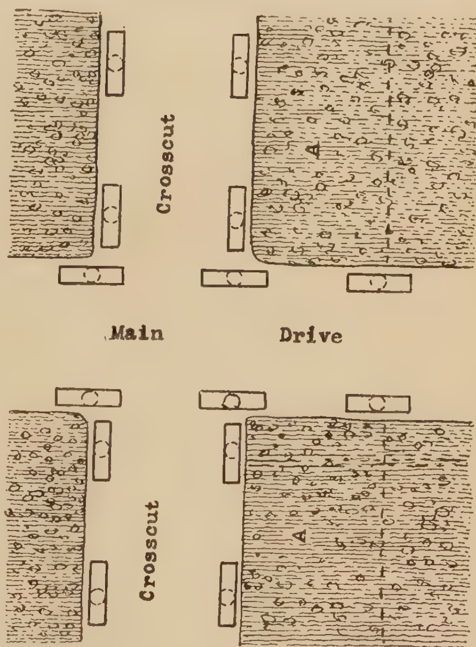


Fig. 294.—Opening out for blocking-out in alluvial ground.

In cases where the gravels forming the back of the workings are heavy, say, for instance, where they carry a good deal of water, or where running sands are met with, more elaborate methods of support have to be resorted to. The main drives themselves need to be timbered solidly, the precise method followed being determined by the nature of the ground and of the bedrock.

If the former is not abnormally heavy, three-piece or four-piece sets such as shown in figs. 133 and 134, spaced about 4-feet to 5-feet centres and lathed in the usual way at back and sides, may be used, but should the ground be of a character likely to run, such methods of timbering as shown in figs. 154, 155, or 162 may be necessary. In actual working such very heavy timbering is not often attempted or needed, for the reasons that before blocking-out or mining in the drift is started, the ground is usually thoroughly drained, and, moreover, ground that is sufficiently rich to pay for it is not often met with. As a general rule, three-piece or four-piece sets, spaced as stated, fulfil all

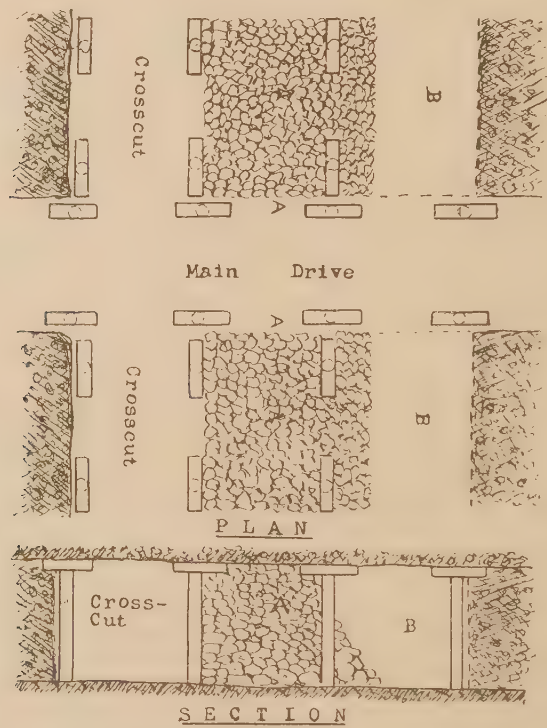


Fig. 295.—Timbering during blocking-out operations.

requirements. In blocking-out in heavy ground, the timbering needs to be somewhat more substantial than in better standing country. In place of posts with breasting-caps, some form of set, or combination of posts with sets, is usually employed. In ground that is only moderately heavy, the use of posts and caps, with additional back laths, as shown in fig. 296, may serve the necessary purpose. In somewhat heavier ground an arrangement of sets such as shown at B (fig. 297) may be more advisable. To enable this method of timbering to be followed, the ground must be at least strong enough to admit of a block 6 feet to 7 feet on each side being removed without timber. A variation on this method is shown at A. This consists of shortening the horns on the drive-set cap sufficiently to provide seats on the posts for backing-off caps, the other ends of which rest on king-posts. As the working extends laterally, further king-posts and similar caps are used. Laths are placed over from cap to cap, and each row of caps is stayed to the row behind it. This is

a simple and effective way of timbering fairly weighty ground, and has these advantages, that all the timber can be prepared at the surface and, as only one

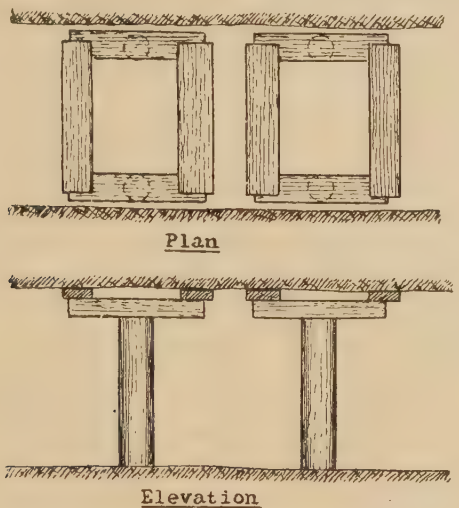


FIG. 296.—Timbering alluvial workings.

post needs to be stood at a time, troublesome ground can be picked up with the least possible delay.

Where there is a tendency of the backs to run, either of the foregoing ways

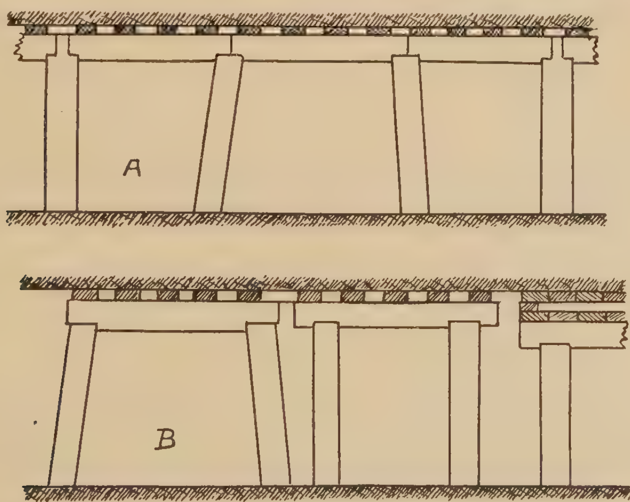


FIG. 297.—Timbering alluvial workings.

of timbering may be used, but it may be necessary to close-lath the back, and to drive the laths as in ordinary fore-poling, a bridge being provided over each cap to enable the laths to be entered for each successive set.

When alluvial ground has to be worked from a shaft, it is possible in many cases, when sinking, to use box-timbers throughout for lining the shaft, but this

can only be done when the ground is uniformly compacted. Where there is any probability of meeting beds of sand, and especially when the horizon of such beds is not definitely known, it is advisable to sink with frame-sets, for this gives opportunity to resort to fore-poling when the bad ground is reached, and may enable the shaft to be carried down safely when otherwise it would be lost. If a shaft is carried down into such ground with box-sets, it is difficult to come back to any point in the shaft and change over to frame-sets, so much caving quickly taking place outside the box timber as to render the whole shaft unsafe.

In opening out from a shaft sunk to develop an alluvial lead, it is not customary to do it immediately on bedrock. The reason for this is that the ground is in many cases heavily charged with water, and to get rid of this it is advisable to get below the lead, consequently the main drive (or crosscut) from the shaft is taken in in the bedrock, occasional jumps-up being put up to the wash, which serve at once to drain the ground and as loading chutes for handling the pay-gravel.

CHAPTER XIII.

SKIP-LOADING POCKETS.

In mines worked from inclined shafts the ore is invariably loaded direct into the skips from a bin or loading-pocket constructed over the back of the shaft. In mines worked from vertical shafts the practice of loading direct in this way is only followed in the larger class, most small mines sending the ore up to surface in the trucks that bring it out from the stope-chutes.

Wherever direct-loading pockets are provided, they are expected to stand up to very heavy service, the pocket on each level having to pass the ore coming from all the stope-chutes on that level, and the wear and tear is thus considerable. For this reason there is a tendency in modern mining to avoid the use of timber in constructing them, as, no matter how strongly it is put in, the cutting effect of the ore soon plays havoc with it. If the rock in which a pocket is excavated is of good standing nature, advantage is usually taken of the fact to dispense with lining of any kind. Failing the presence of good natural rock walls, resort is had to concrete and steel. In some cases, however, mine managers prefer to use timber for the pockets, and, in others, there may be reason why its use is compulsory. A description, therefore, of a few typical examples of timber-lined pockets may be of interest and service.

These ore-pockets may be said to be of two general types. In one of these the loading is done through a single gate into the skip, in the other it passes from the main bin into an auxiliary measuring-pocket, and thence into the skip. In most large mines the latter type is now adopted, the reason for this being that by measuring the load only sufficient ore escapes at any one time just to fill the skip, and there is thus no overflowing of material into the shaft.

ORE-POCKETS FOR DIRECT-LOADING IN VERTICAL SHAFTS.

A simply constructed pocket for direct-loading in a vertical shaft is shown in fig. 298. The natural rock forms the two ends. On the side at which the pocket is placed the shaft is widened out several feet, and extension-sets, framed in a similar way to the ordinary shaft-sets, are erected, and on the pocket side of these, hardwood planking from 2 inches to 4 inches thick is spiked vertically. To form the plat, strong beams are hitched into the rock at the top of the bin. A chute gate operated by rack and pinion is provided, as is also a tumbling lip which may be raised or lowered at will. If rapid winding in the shaft is customary, it is advisable to bolt the shaft and extension timbers firmly together.

Fig. 299 illustrates another small pocket for a vertical shaft. Here the rock forms one side, the two ends, and the floor. The shaft is widened out in the same way as when constructing the pocket shown in the previous illustration,

but instead of the extension timbers being framed similarly to the shaft-sets, uprights of sufficient length to span from the plat sills to the bottom of the pocket chamber are stood on the pocket side opposite the shaft end and each divider.

Yet another method of timbering the chamber is shown in fig. 300. In this,

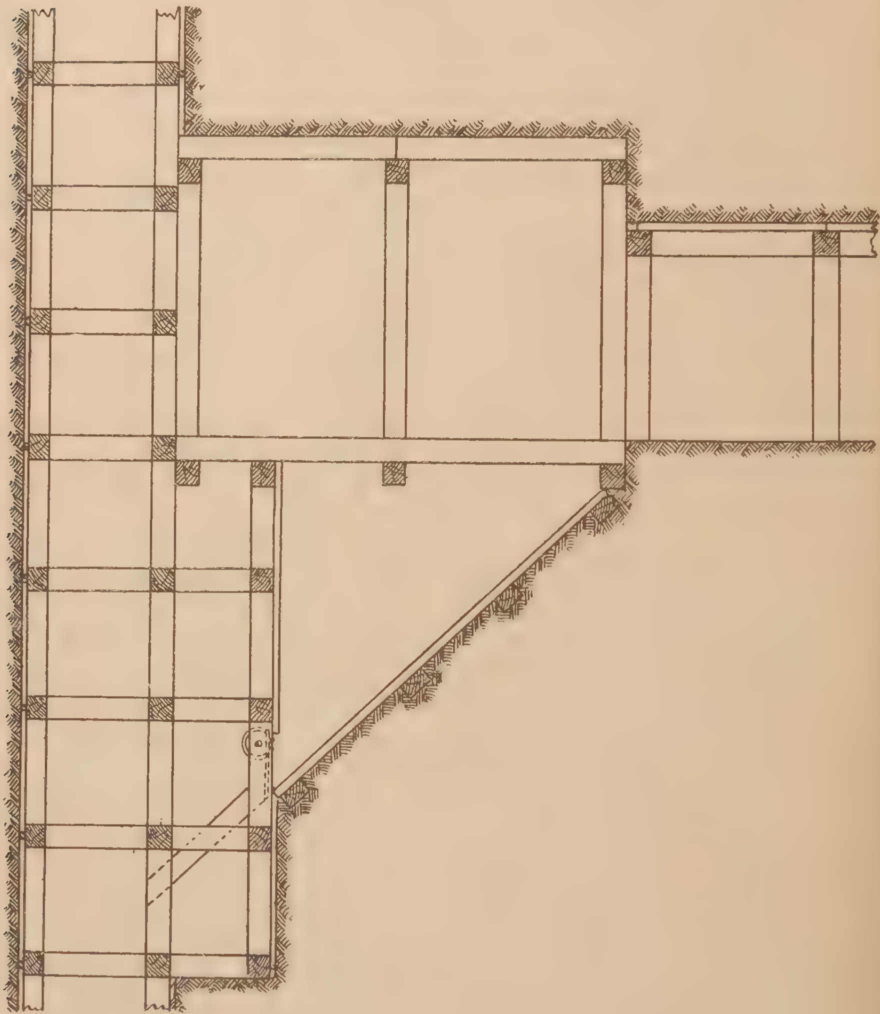


FIG. 298.—Skip-loading pocket for vertical shaft.

bearers are placed in hitches in the shaft just below what is intended to be the floor of the chamber, and on them, specially framed timbers are built up to the level of the plat. The end-plates, being in one piece, give great strength to the entire construction.

In cases when the surrounding rock is of such a nature that a pocket can be made in it without the necessity of lining it with timber or any other class

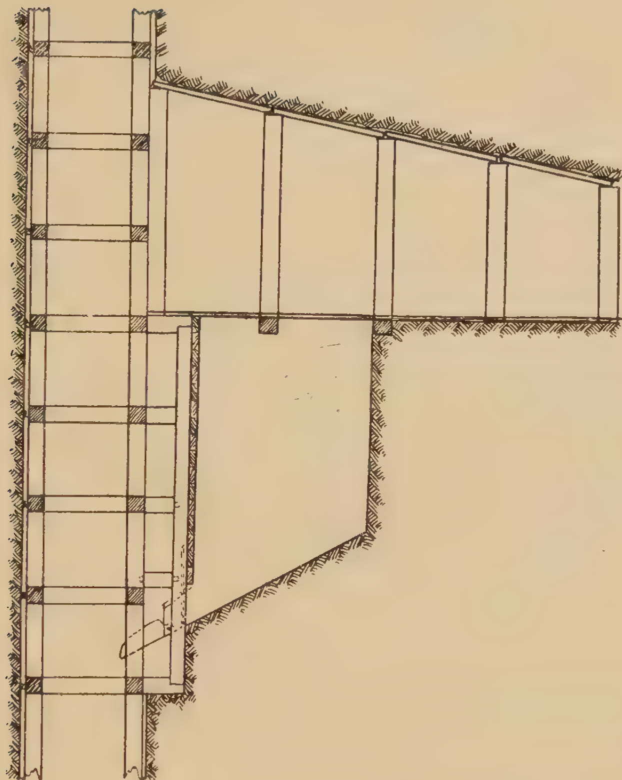


FIG. 299.—Skip-loading pocket for vertical shaft.

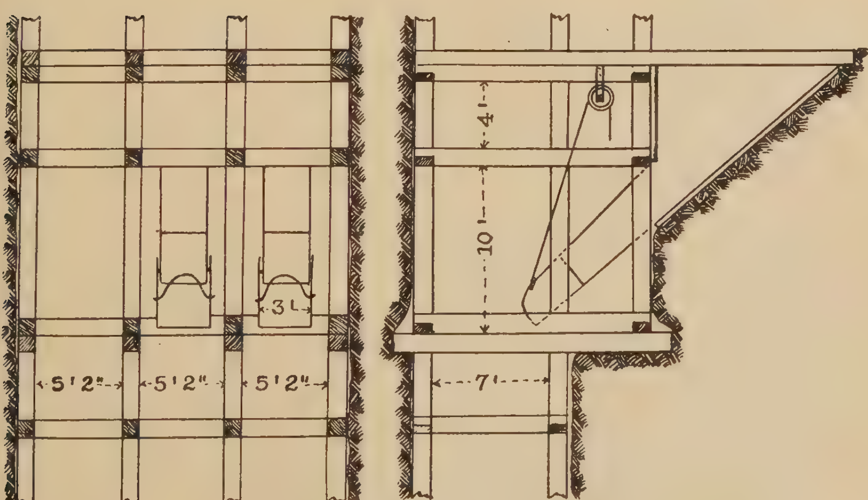


FIG. 300.—Skip-loading pocket for vertical shaft.

of material, and where large storage-room is required in the bin, a chamber is opened out from the shaft as shown in fig. 301, from the rear of which the pocket is raised in an inclined direction. All the timbering that is then called for is

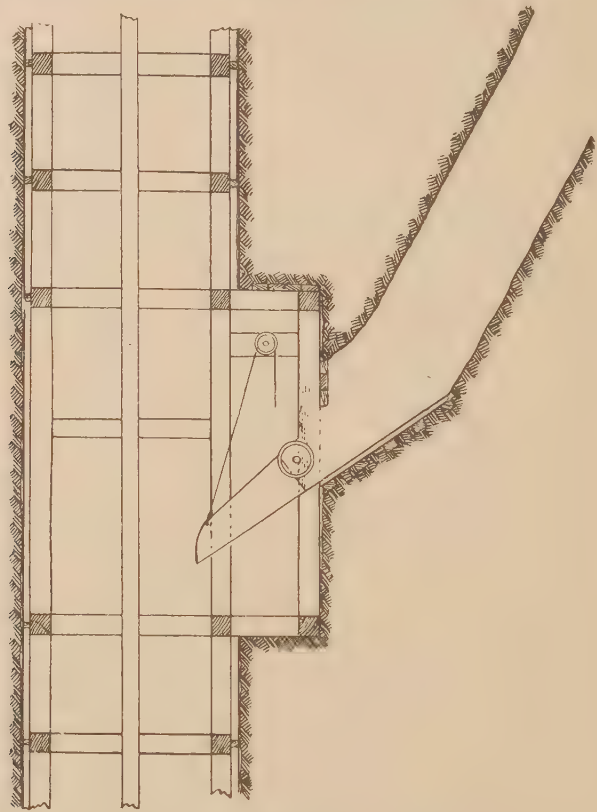


FIG. 301.—Skip-loading pocket for vertical shaft.

merely such as is needed to secure the chamber and admit of the construction of the chute gates. A pocket of this kind can be made to hold a large tonnage of ore, as it may be any depth the distance between levels will permit.

DIRECT-LOADING ORE-POCKETS FOR INCLINED SHAFTS.

Fig. 302 shows the construction of a small pocket for direct-loading in an inclined shaft. A pocket of this kind is necessarily of very limited carrying capacity, but it may meet all the requirements of a mine having a comparatively small output. The pocket lies directly on the hanging-wall timbers of the shaft, but as the weight of ore it will contain at any time is insignificant, this need not be a disadvantage. The arrangement of the timbers is sufficiently obvious to dispense with any need for detailed description.

Fig. 303 shows the timbering of another small pocket suitable for an inclined shaft, which is of even simpler construction than the last described. Only the two sloping sides are timbered, the planking on one being spiked to

the shaft timber, and on the other to bearers bedded on the rock in which the bin is excavated.

In the construction of the pocket illustrated in fig. 304 some rather different features are presented. This type of pocket is suitable for flat inclines, and in ground that does not stand up too well. The timbering is built up in much the same way as frame-setting in a shaft. If necessary, lagging is placed around

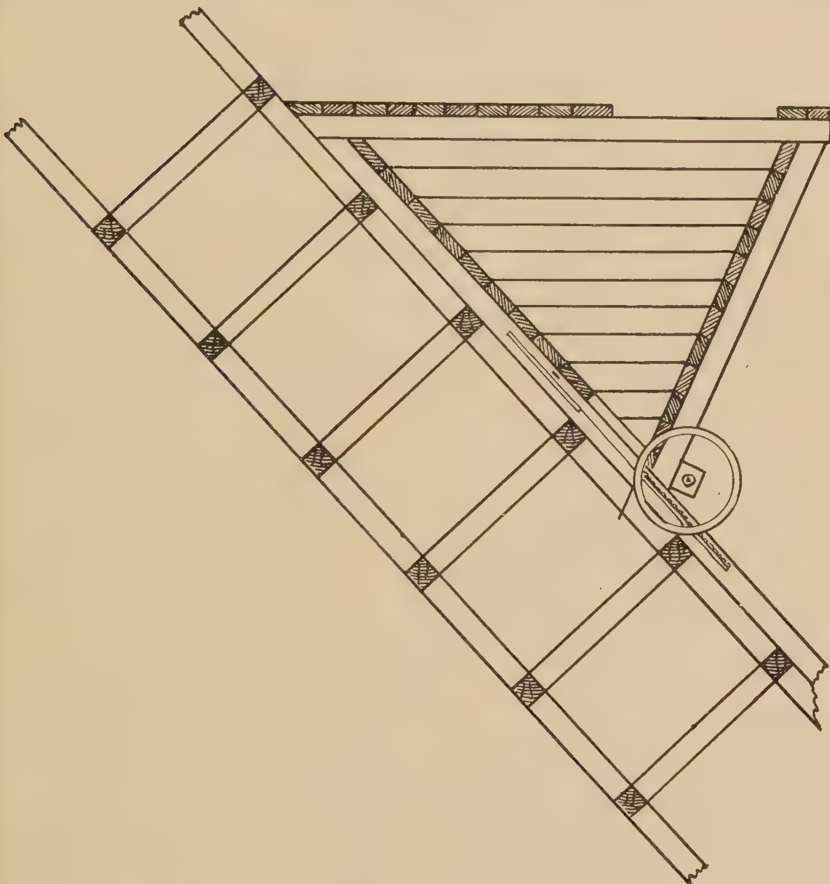


FIG. 302.—Skip-loading pocket for inclined shaft.

the outer side of the frames to support the ground, but it is advisable also to line the pocket inside to protect the sets against undue wear and tear.

In a large mine it is usually necessary to have the pockets of larger holding capacity than those shown in figs. 302 to 304, consequently they are made fairly deep. Fig. 305 shows a method of forming them followed in the Mt. Morgan Mine, Queensland, as described by White and Sewell (51). The pocket is made, as usual, in the hanging-wall, but it is placed at such a distance from the shaft station as will enable the required storage-room to be secured. In the illustration, the depth of the pocket from the level to the top of the sloping floor is 62 feet. The pocket is 8 feet by 8 feet at the top, but opens out at the bottom to 12 feet by 8 feet. It is closely timbered with *gwyndered*

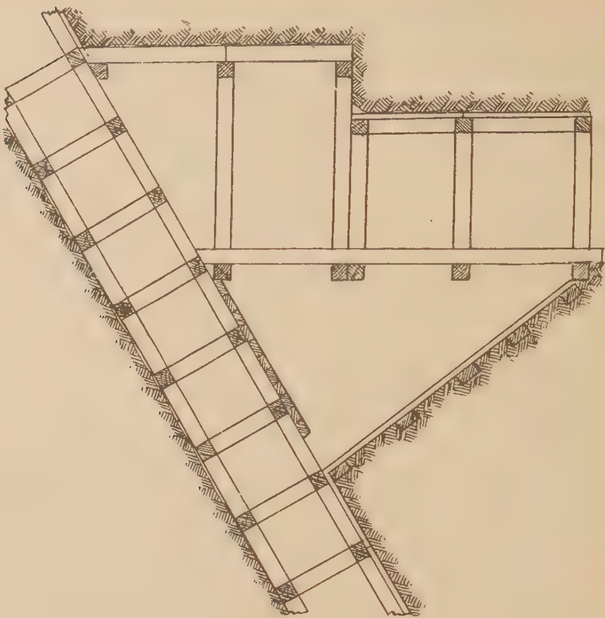


FIG. 303.—Skip-loading pocket for inclined shaft.

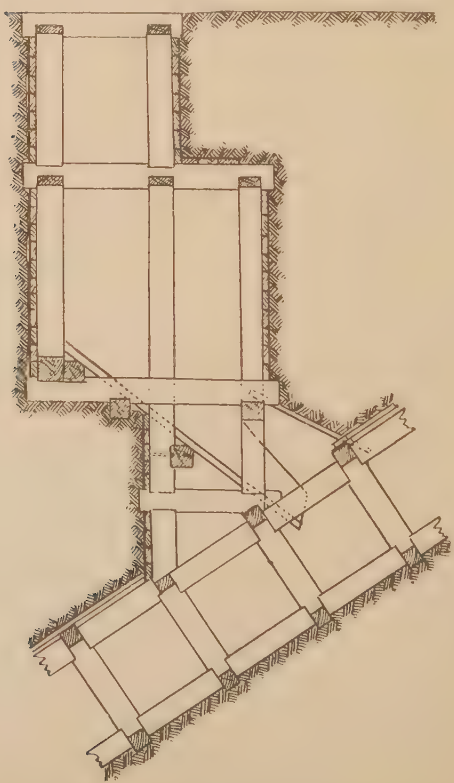


FIG. 304.—Skip-loading pocket for inclined shaft.

sets, and bearers are put in at about every 15 feet. The sets themselves are further lined with vertical hardwood planking. A pocket timbered in this way will give good service, and has this advantage, that all the wear comes on

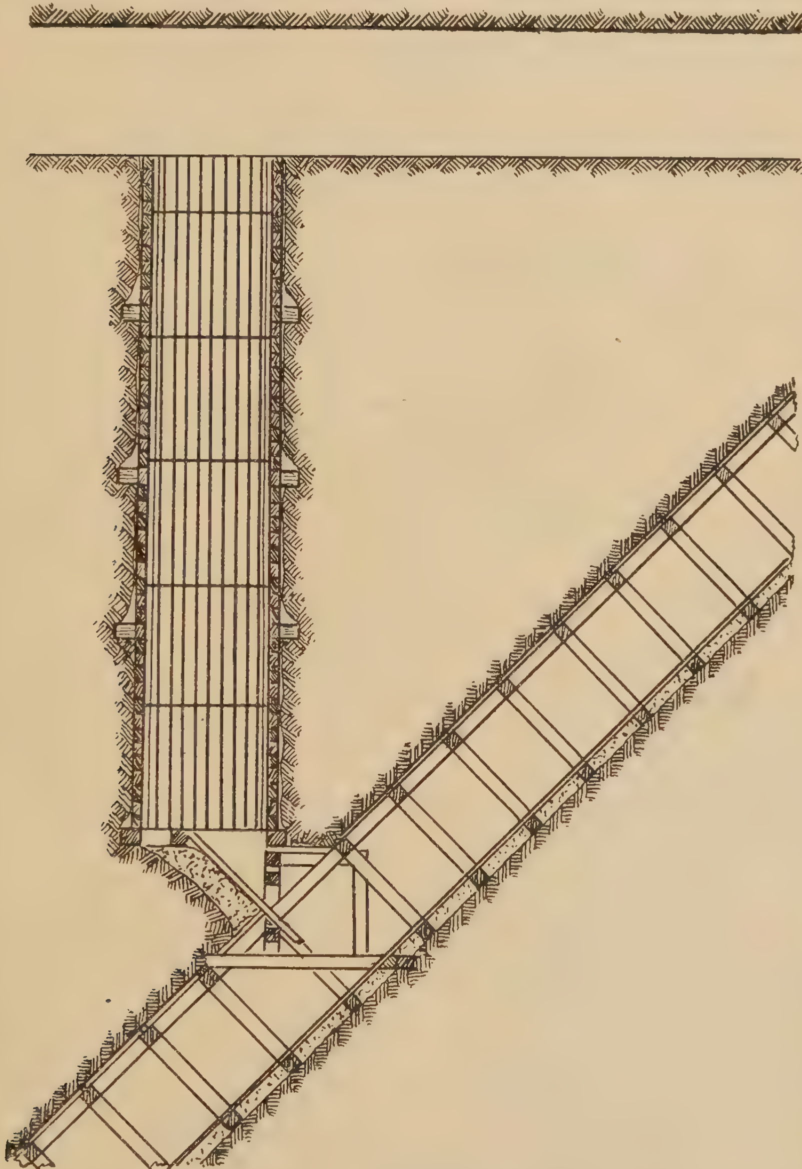


FIG. 305.—Storage-bin and loading-chute for inclined shaft.

the vertical planking which can be readily replaced when it becomes badly worn.

Another method of timbering a similar type of bin is to use heavy frame-sets in exactly the same way as in a shaft, hanging them and lagging them if

necessary, in the usual way, then lining them inside with vertical planking. In place of the latter, the method of *bricking* with short blocks set end on to the wear is sometimes adopted. This method is illustrated in fig. 266.

SKIP-LOADING POCKETS WITH AUXILIARY MEASURING-HOPPERS.

When measuring-pockets are provided a somewhat different arrangement of the chamber timber is necessary. Fig. 306 illustrates the same small type

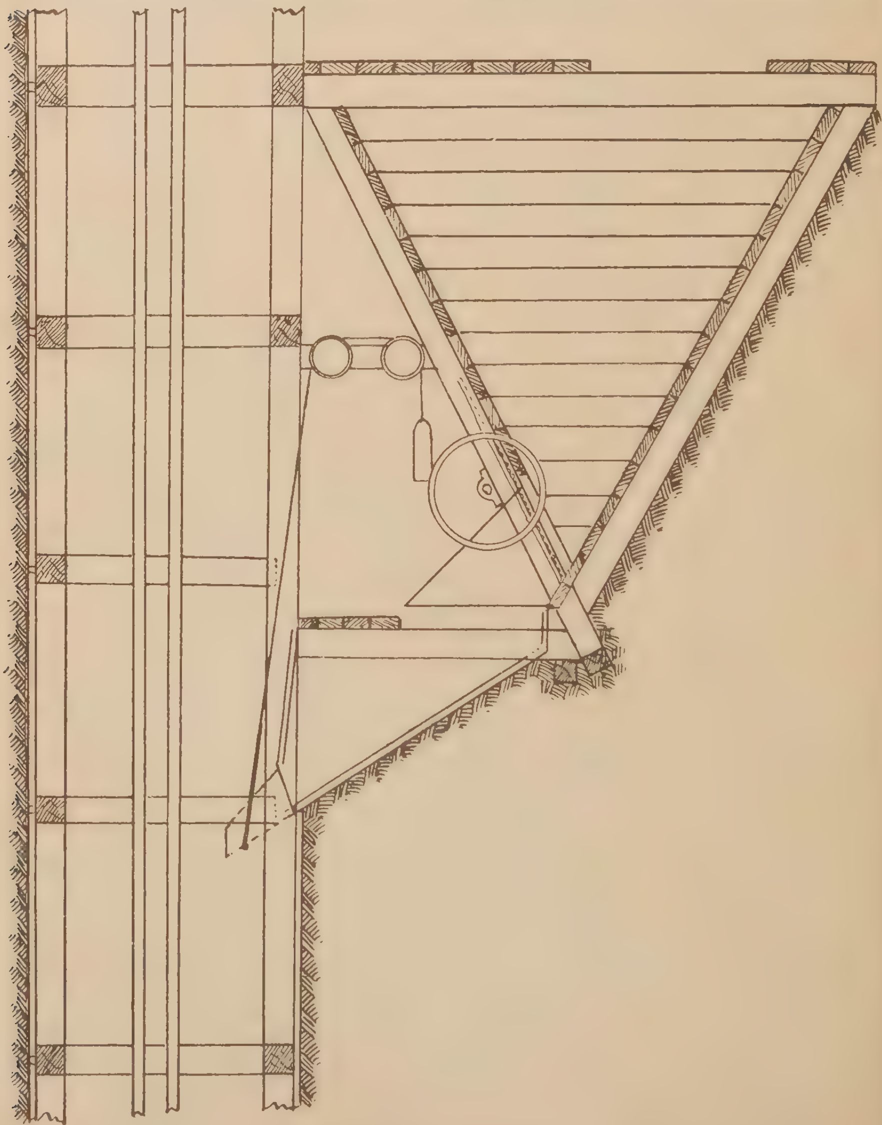


FIG. 306.—Loading-chute with measuring-pocket for vertical shaft.

of pocket as shown in fig. 302, adapted for loading skips in a vertical shaft through an auxiliary pocket. In constructing a pocket of this kind, a chamber is excavated from the shaft sufficiently large to enable the pocket to be built

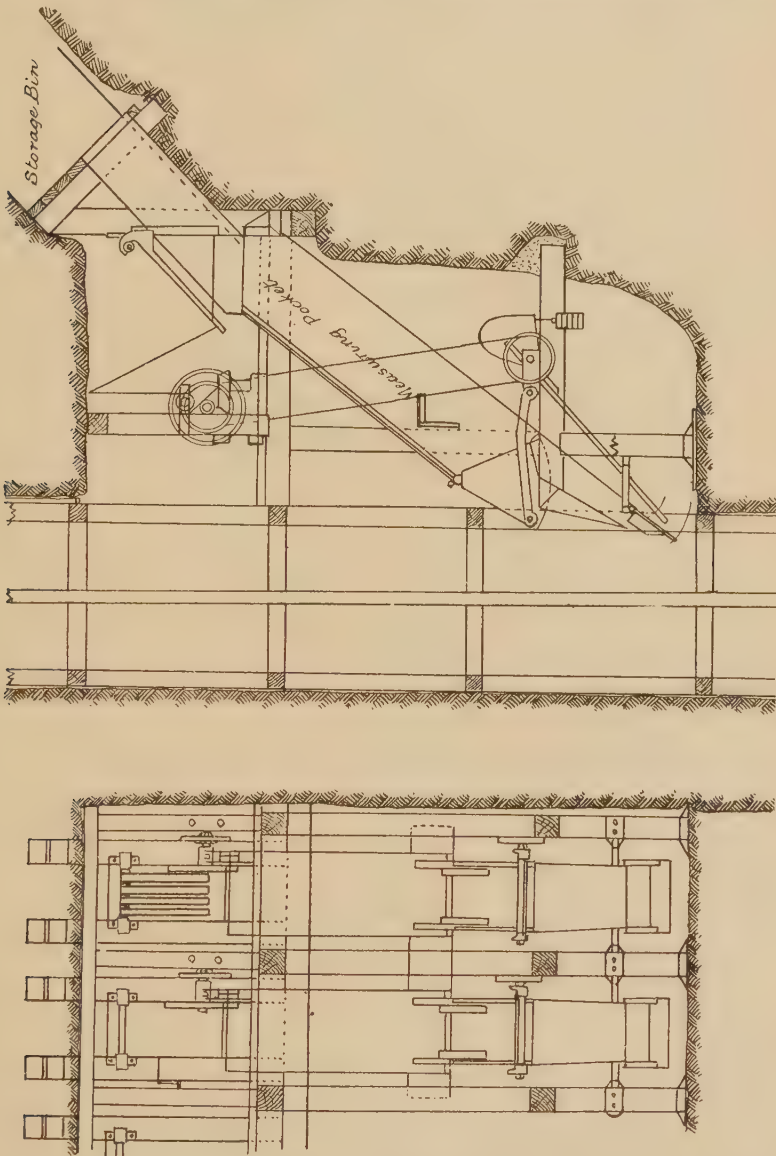


FIG. 307.—Loading-chute with measuring-pocket for vertical shaft.

up within it. A space is thus left between the bin and the side of the shaft which admits of the skipman crossing from side to side to operate the gates in the different compartments.

Pockets such as the last three illustrated are only suitable for mines using comparatively small skips, say of about one ton capacity. In some mines,

skips that hold upwards of six tons are now in use, and much larger hoppers have to be provided to supply them. This means that considerably more room is required in the chamber at the foot of the main storage bin, and much heavier timbering is called for. Figs. 307 and 308 will serve to give a general idea of the methods of timbering such chambers in the case of a vertical shaft, and

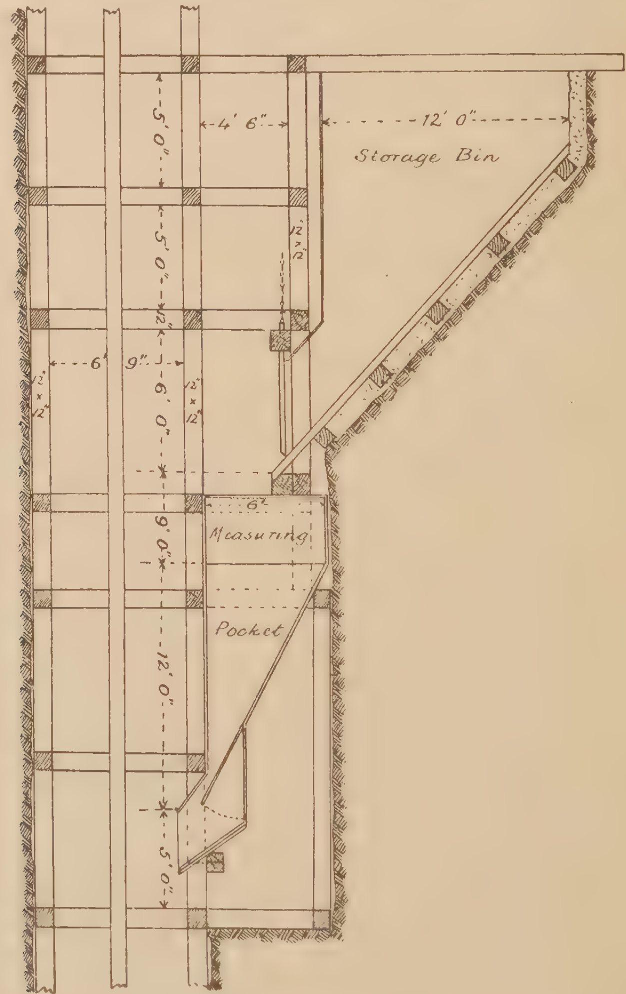


FIG. 308.—Loading-chute with measuring-pocket for vertical shaft.

figs. 309 and 310 in that of an inclined shaft. The measurements given in several of the illustrations are only meant to serve as a general guide, the dimensions of any particular construction of this kind must depend on a number of considerations, such as the class of timber available, the nature of the ground, the size of the skips, the width of the shaft compartments, and the type of mechanical device that is to be used for operating the chute gates. In all cases the measuring-pocket is constructed of cast iron or steel plate. In some instances both the gate on the main bin and that on the measuring-

pocket are opened and closed by means of machinery operated hydraulically or by compressed air, but very often only the latter is worked in this way, the upper gate being operated by hand. It is common also for both gates to be worked by hand. In most of the examples given a tumbling lip delivers the ore from the measuring-pocket to the skip. This lip is raised or lowered

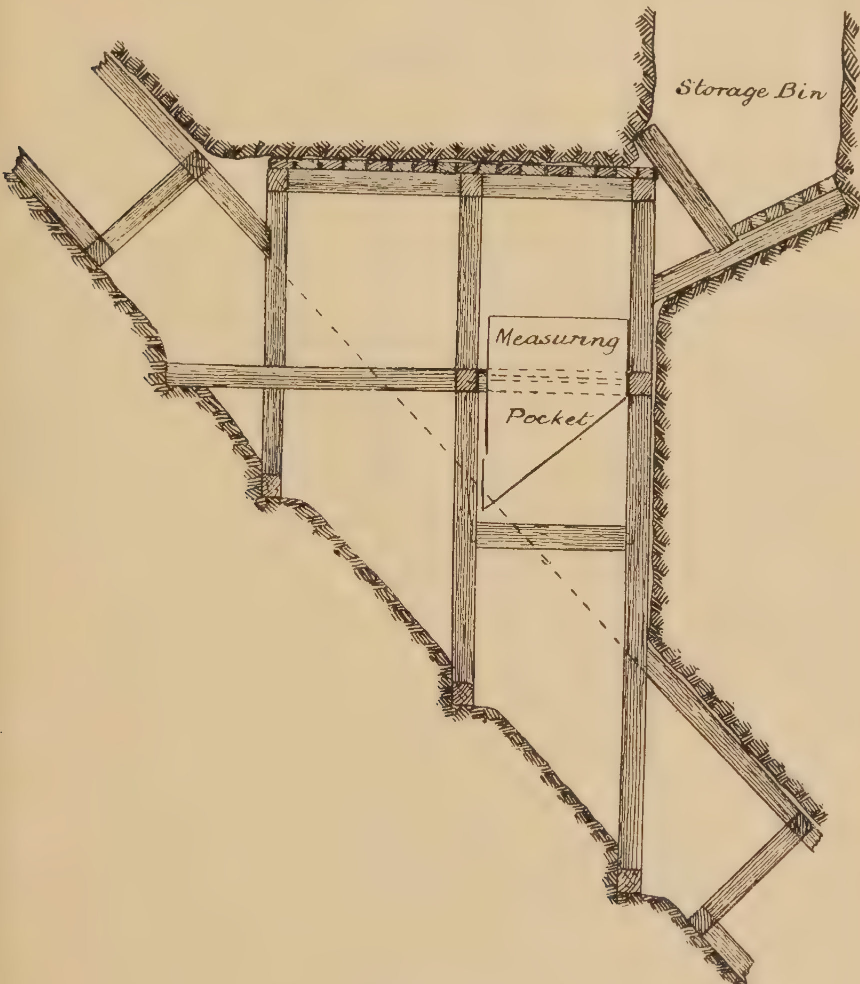


FIG. 309.—Loading-chute with measuring-pocket for inclined shaft.

by means of a flexible wire rope which is fastened to it at one end, passes over a pulley rigged at the roof of the chamber, and is loaded at the other end with a counterweight. As a rule, the upward movement of the skip as it leaves the bin raises the lip out of the way into a position where the counterweight holds it until the latter is lifted again. There is always a certain amount of danger, however, of the lip being left down, owing to an oversight on the part of the skipman, with the result that it is torn off by the descending skip, and on account of this some mining engineers prefer either to dispense with it

altogether or else fit it in such a way that if it is caught little damage will be done. Thus, in the loading arrangement shown in fig. 308 no lip is used, and on the lip shown in fig. 307 the part that projects out over the skip during

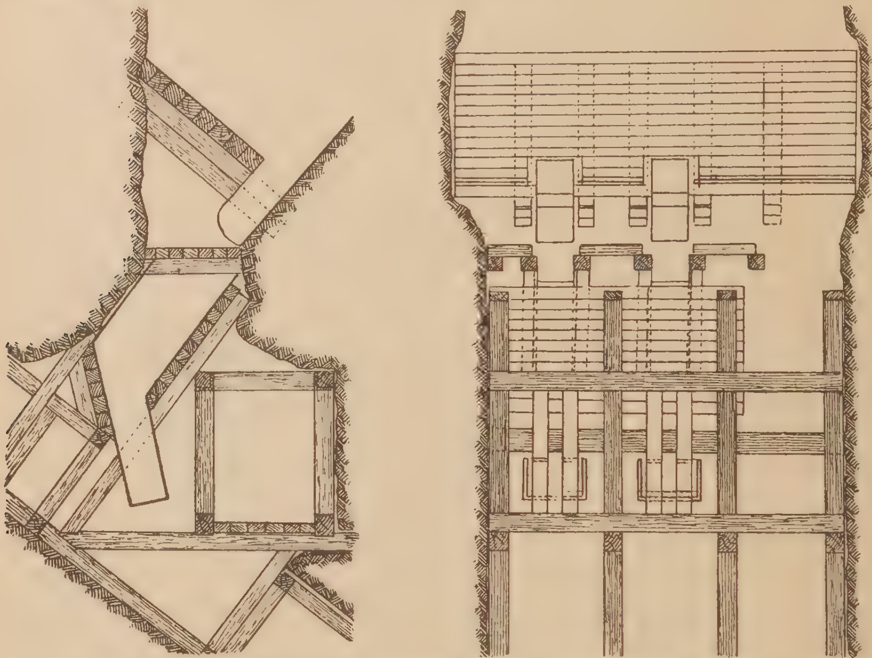


FIG. 310.—Loading-chute with measuring-pocket for inclined shaft.

loading operations consists of a liner attached lightly by two bolts to the short-hinged apron, which is torn off easily, should the skip start prematurely, without doing further damage.

CHAPTER XIV.

UNDERGROUND WOODEN DAMS.

THE use of dams underground is mainly for temporarily holding back drainage water in a level, or to cut off serious inflows from old workings. A good deal can be done in the direction of holding back ordinary ground water by the

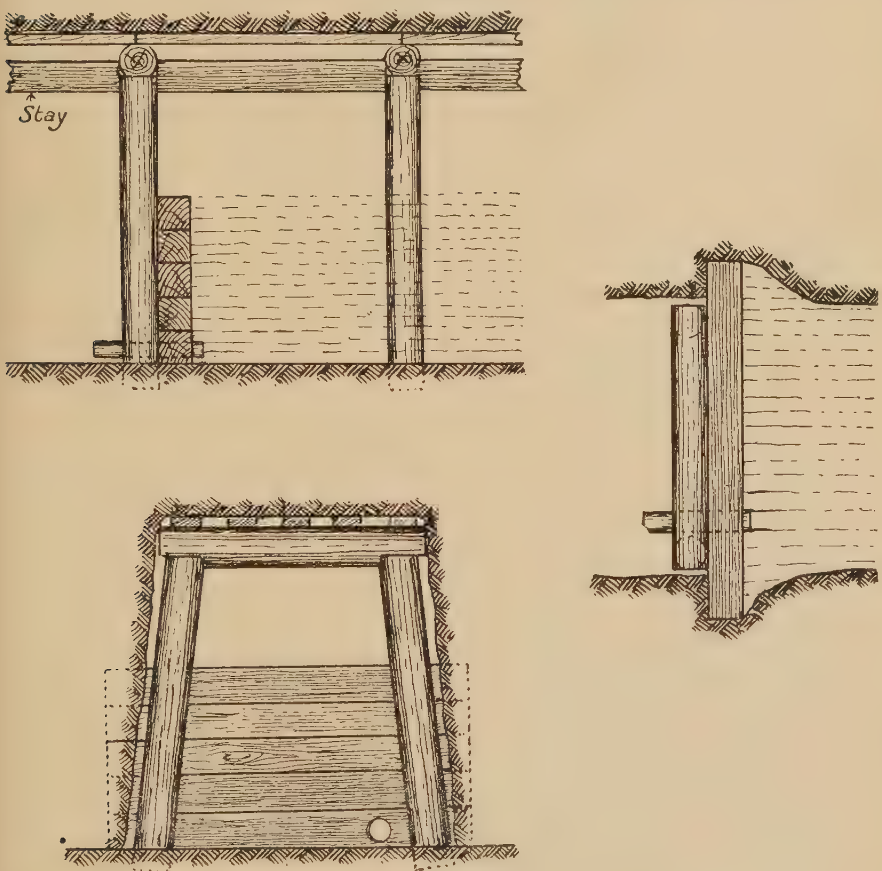


FIG. 311.—Temporary wooden dam in drive.

puddling of shafts or the lining of them with close tubbing, but in addition to this, circumstances often arise when very solid dams have to be put in to effect the desired purpose.

If a dam is required to withstand high pressure, modern practice leans largely to constructing it of brickwork, masonry, or concrete. Timber is, however, still used under such circumstances, and will doubtless continue to be used for years to come, consequently these pages would not be complete without some brief description of the various ways in which dams are constructed of this material.

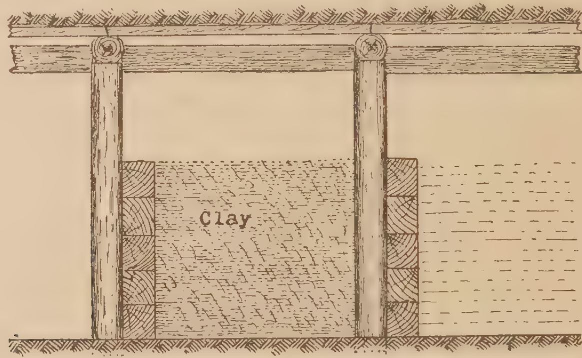


Fig. 312.—Temporary wooden dam with clay packing.

If the dam is merely required to form a temporary sump to retain water in a level, say, during pump repairs, or to enable it to be lifted by a pump to the surface at suitable intervals, the construction may be of very simple type, as in fig. 311. A good sound set in the level is picked out, or, better still, a new set of squared timber is put in, and immediately inside this the sides and bottom of the drive are trimmed as smoothly as possible. If the ground is of a nature that cannot be dressed evenly, it is trimmed off as well as circumstances permit, and a facing of cement placed on. A piece of tarred felt is laid on the bottom, and the first piece of cross-timber put in position behind the set. On top of this a further piece of tarred felt (or similar material) is placed and a second cross-piece put in, and so on till the required height is reached. Each piece of timber as it is placed is wedged tightly and closely at the ends to prevent water leaking past. Near the bottom, an outlet is provided to allow of the water being drawn off, but if the latter is pumped direct from the sump this provision is not necessary.

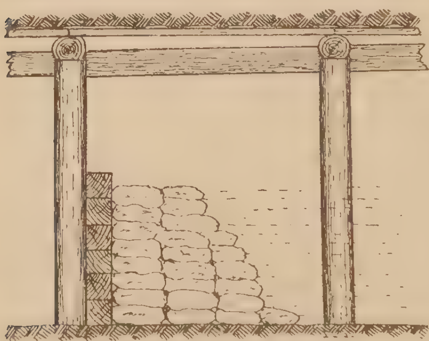


Fig. 313.—Temporary wooden dam.

Another method of making a small dam of this description is shown in fig. 312. This consists in building a double wall of timber across the drive or crosscut, and packing the intervening space closely with suitable clay. In making a dam of this description it is not so necessary to trim the sides and bottom of the working for fitting the timber, as the clay, if well rammed or puddled, will stop any serious leakage. The timbers should, however, be firmly wedged in place.

Instead of building the inside timber wall it may be sufficient for the

required purpose merely to place loosely filled sacks of clay inside the first wall, as in fig. 313. In a short time these pack together tightly and close all interstices.

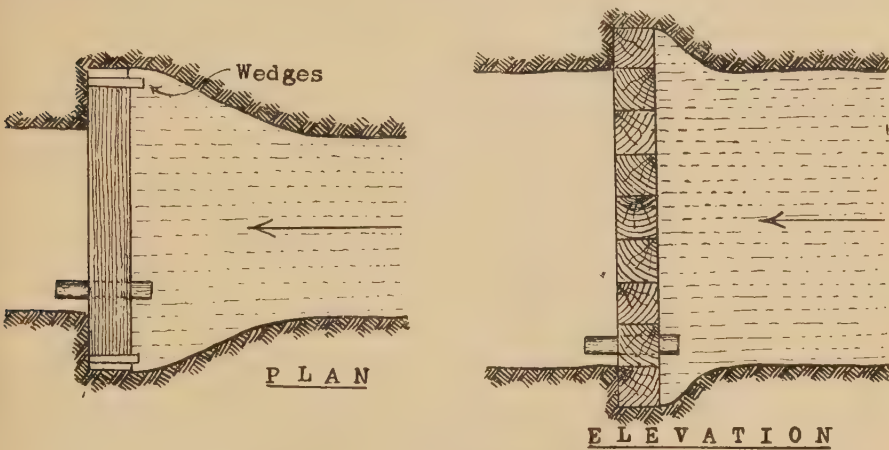


FIG. 314.—Timber dam to withstand a moderate pressure.

If it is desired to build the dam to the full height of the drive, a single wall of timber may prove a quite satisfactory stopping, provided no great pressure is expected to come on it. In this case, the rock at sides, top, and bottom

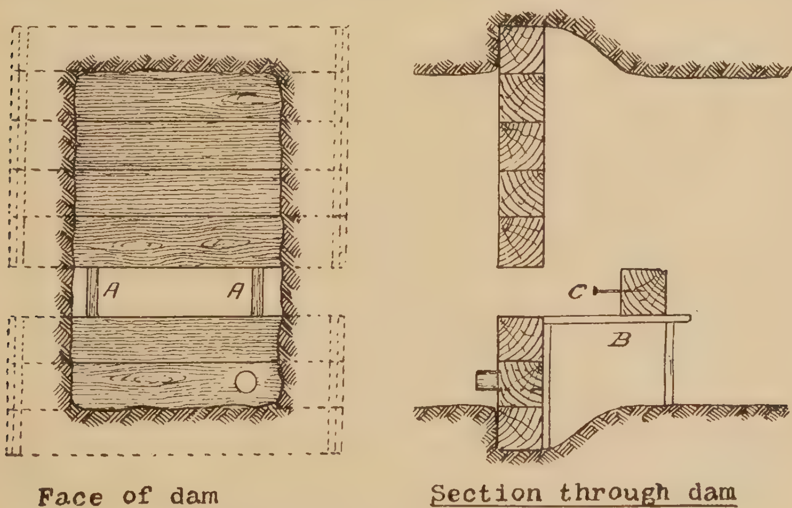


FIG. 315.—Method of constructing dam shown in fig. 314.

must be dressed until the surface is quite smooth, to receive an equally smooth surface of timber. Tarred felt is laid under the bottom baulk and over the top one, but the rest of the timber is merely laid skin to skin, as in fig. 314, and the joints are subsequently well caulked from the outside when the dam has been entirely erected. Each baulk as it is put in position is closely wedged at the ends. To afford ingress and egress to the workmen, one of the timbers near the centre is left out till the last, as in fig. 315, temporary chocks AA of

the right thickness being put in to enable the upper timbers to be secured in correct position. As it is impossible to wedge this closing-up baulk in place, it must be cut to a neat fit. When all the rest of the timber is in place this baulk is mounted on a small staging, as at B, and after the men pass out through the opening it is drawn into its place by means of two spikes CC driven into it. The whole of the joints are then carefully caulked. A little leakage is almost sure to occur, but this should not cause inconvenience.

For heavier pressures, much more substantial construction is called for, and it is usually along some such lines as shown in figs. 316 to 318. The first mentioned illustration, together with the following description, is taken from the *Engineering and Mining Journal*, vol. xciii. No. 3. Built of sound oak, it is claimed a dam of this type will withstand a pressure of 100 lb. per square inch. The timber should be thoroughly seasoned and dressed to shape and size required in tapered voussoirs or baulks 9 feet long. The dam should be

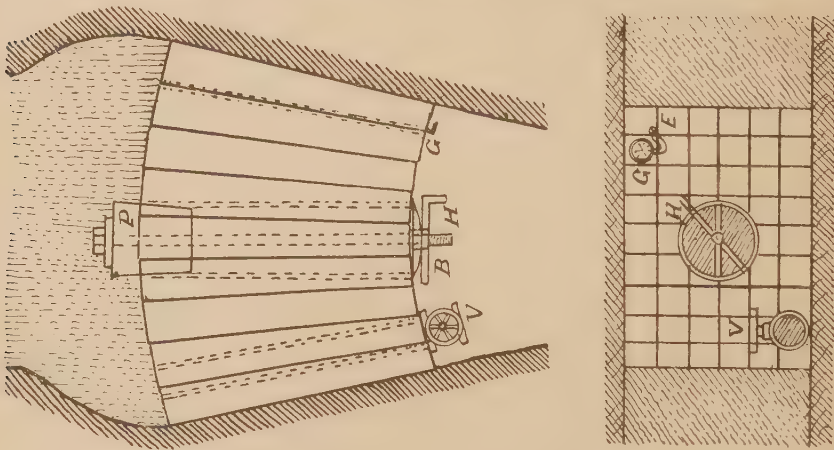


Fig. 316.—Timber dam to withstand high pressures.

built in solid ground, the sides, roof, and floor being dressed perfectly smooth. No explosives should be used in preparing the site, in order to avoid shattering the rock. At the end nearest the water each side should be enlarged 2 feet, making a total width of 12 feet, and the roof and floor should be enlarged 1 foot, making a total height of 8 feet. The area of the dam nearest the water would then be 96 square feet, and the other end 48 square feet. All the pieces of timber forming the dam should be prepared, fitted together, and numbered at the surface in order to ensure good tight joints when they are permanently fixed.

Before the voussoirs are laid in place, a thick layer of tarred cloth is put against the sides, floor, and back of the prepared site. The timbers are then placed in with their large ends towards the water. Tarred cloth is also placed between each separate baulk. When all the timbers are in place, all the joints are wedged up from the inside of the dam, the wedges used being of soft wood, 2 inches long, 1 inch thick, and 3 inches wide. If water is present during the construction, a pipe is placed near the bottom of the dam to allow it to escape. Near the centre of the dam a further pipe, about 18 inches to 20 inches diameter, provides ingress and egress to the workmen, while near the top a small pipe is inserted to admit of the escape of any gas that may form. The baulks sur-

rounding these pipes are shaped to fit them. When the wedging has been completed, the men pass out through the large pipe, and draw in behind them the tapered plug P, the thick end of which is covered with vulcanised rubber. This plug is tightened into the pipe by means of the long bolt B and the handle H. A valve V is placed on the outlet of the water-pipe at the bottom of the

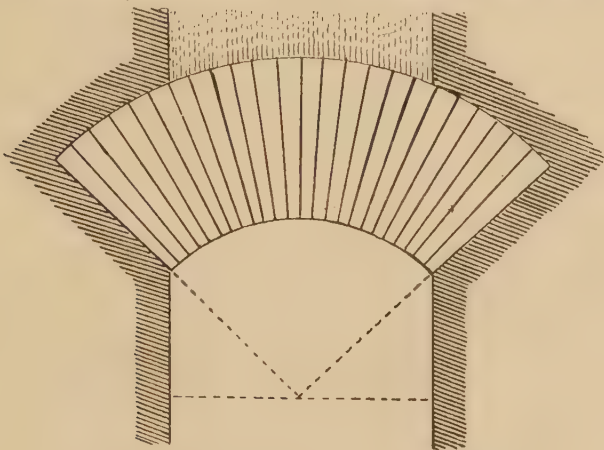


Fig. 317.—Timber dam to withstand high pressures.

dam, and on the air-pipe is placed the gauge G which serves to indicate the pressure on the construction.

The dam shown in fig. 317 has been described by Faulds (65) as having been constructed in the Extension Mine, near Nanaimo, Vancouver Island, owned by the Wellington Colliery Company, Limited, in order to flood the mine after

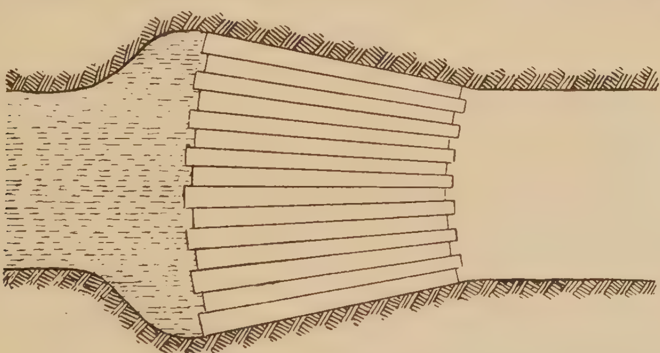


Fig. 318.—Timber dam to withstand high pressures.

a fire in which a considerable number of lives were lost. It was built in a tunnel 15 feet wide by 8 feet high, in sandstone. The roof, sides, and floor were carefully prepared by trimming to a perfectly smooth surface. The timber used for the voussoirs was Douglas pine, and tarred brattice curtain was employed in place of felt or flannel. The voussoirs were 8 feet long, and tapered from 8 inches by 12 inches to 8 inches by 8 inches at the smaller end. Between each course and between each voussoir, well-tarred brattice curtain was laid, and after all the voussoirs were in place the whole construction was

thoroughly wedged in the usual way. A temporary clay dam was erected on the inside of the permanent dam, and the water was conducted therefrom through an exit pipe made of steel and large enough to allow a man to crawl through it. This pipe was subsequently closed with a well-stayed blind flange on which a gauge was fixed for recording the pressure. The pressure or head was 130·2 lb. per square inch. The radius of the extension of the dam was 20 feet, that of the interior 12 feet, and the height 9 feet.

In the type of dam shown in fig. 318, also described by Faulds, the voussoirs are from 4 feet to 5 feet long, according to the pressure, squared and tapered according to the radius of the arch to be formed, and laid side by side in rows with the joints breaking bond. Tarred cloth of some kind is used between the rows and the separate baulks, and the whole construction wedged as in the other cases. A way of ingress and egress for the men during construction is provided by a conical cast-iron pipe built in near the bottom of the dam, any water that may be present being led out through it by means of flexible tubing. When the dam is completed this pipe is closed, as in fig. 316, by a tapered plug, covered at its larger end by vulcanised rubber. If it is desired to provide for escape of air a small hole is drilled through a voussoir near the top of the dam, which, when all the air has escaped, is plugged with wood.

CHAPTER XV.

MAINTAINING AND REPAIRING SHAFTS AND LEVELS.

A TIMBERED shaft, especially if vertical, requires at all times careful watching, and should be systematically examined at regular intervals. In nearly all mines of any importance this examination is made at least once in each week, sometimes on a shift when the ordinary hauling can be suspended for a few hours, sometimes on the Sunday. The work is known to miners as "going through" the shaft, and it is usually entrusted to the men ordinarily in charge of the underground loading, namely, the skipman or chamberman and his assistant, although in some mining districts one of the foremen accompanies them.

REPAIRING GUIDES IN SHAFTS.

Of all the timbering, the guides probably need the most attention in the general run of mines. If these have been merely secured in the time-honoured way by means of coach-screws, the vibration resulting from rapid winding causes the screws to break in numbers, with the consequence that if they are not replaced without delay the guides may be torn away, to the great danger of the shaft and winding-gear. As a rule, broken screws remain in the guide and are not readily detected. In going through the shaft, therefore, the men try every screw by tapping it with a hammer; they are lowered quietly in the cage, one man taking each side and testing each screw as it is reached. Nearly all modern cages have a long slot provided in the shoes or runners which allow this examination to be made readily. The slot is wide enough to enable a box-spanner that fits the heads of the screws to be operated through it. If a screw is found to be loose, the cage is stopped by a pull on the signal line, and the broken screw is at once removed and replaced by a new one. The point of the broken screw cannot be drawn, hence a fresh position has to be found for the new one. In a boxed shaft this presents no difficulty, but in a frame-set shaft it occasionally happens that a divider becomes so full of broken screw-ends that it is impossible to find a place for a fresh screw, in which case a new divider has to be put in or a piece of timber spiked down on top of the old divider, as shown in fig. 75, to allow of the guide being properly secured.

In case a guide is found to be split, it must also be repaired at once. If the split is not extensive, the driving of a few stout nails in the timber may enable the guide to be used for some further time, but if the splitting is at all serious the guide should be replaced. To avoid delay, a number of spare guides, fully prepared except for the boring and countersinking of the holes for the coach-screws, should be at all times available. The holes cannot be bored beforehand for the reason that the position in which the screws will go cannot be determined till the guide is stood in its place in the shaft.

If only a guide here and there has to be replaced, and the timber used is

not of large section, a very common way of performing the work is for the men to bring the cage to a position from which the uppermost coach-screw can be first removed. The cage is then lowered to the position of the next lower screw which in turn is taken out. One of the men ascends to the top of the cage-hood and steadies the guide in place while the cage is very slowly lowered and the remaining screws removed. The second man now climbs to the hood also, and the two of them, easing the guide out of its place at the bottom end, lower it into the cage. A short piece of lashing is next used to secure the top of the long timber to the winding-rope above the cage, and the guide is taken to surface or to the nearest level. The new guide is then placed in the cage, and when the latter has been lowered to the top of the gap left where the old guide had been removed, it is stopped, and one of the men ascends to the hood. The cage is then once more very slowly lowered, the men guiding it by pressing lightly against the other shaft timbers until the shoe engages with the run of guides below, the cage being allowed to descend until the top of the latter shows above the shoe. The men lift the new guide bodily up to the hood, and place its lower end on the fixed guide beneath, following this by gently pushing the top end into position. If the guides are cut to standard length the timber should go easily into its place. The hole is bored and countersunk for the bottom coach-screw, and this is inserted and screwed nearly home. One of the men now descends into the cage, which is raised to the position of the next screw in upward succession, the man on the hood meanwhile steadying the guide. The hole for the second screw can now be bored from the inside of the cage, and after this screw has been put in the cage is again raised to the next position, and so the work proceeds till the guide has been fully secured.

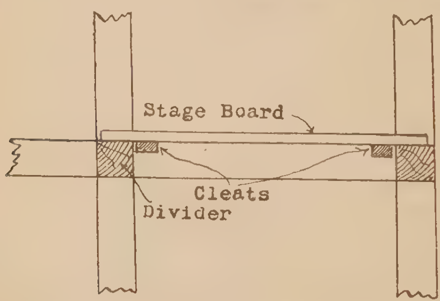


FIG. 319.—Staging for use during shaft repairs.

Replacing a Run of Guides.—If the guides are of heavy section, or if any number of them have to be put in, it is more economical and safer to carry out the replacement work from platforms placed in the compartment. At the chamber immediately below that portion of the shaft being attended to, a solid covering (penthouse) is placed in the compartment. This usually consists of two layers of strong timber laid in opposite directions. All the new guides likely to be required are then sent down to this level. At the level above the work, a stout beam is then set across the compartment, generally on the first set below the plat. Through the centre of this an eye-bolt is passed, to which a block is shackled. A hole is also bored near each end of the beam, through which a short piece of lashing is passed. This lashing is used to lower the beam into place, and is subsequently made fast to the shaft timber. To prevent further any possibility of the beam slipping, it is joggled 2 inches deep at each end, the shoulders of the joggles fitting against the dividers.

Work is carried on upwards from the lower plat. Four stages or platforms are put in in such positions that the men working on them can conveniently reach the various coach-screws. The stages are of 8-inch by 2-inch or 10-inch by 2-inch plank, cut in lengths sufficient to span over from divider to divider, or wall-plate to wall-plate, each separate piece having cleats nailed under it,

as in fig. 319, to prevent slipping. If the shaft is frame-setted, the stages may be easily put in place from the ladder-way, but in a boxed shaft they are usually carried up in the compartment as the work progresses. Four men should be employed, one on each stage, and each is furnished with a complete set of such tools as he is likely to need.

Before an old guide is freed, a hole is bored in it with a $1\frac{1}{4}$-inch auger near the top, through which the bolt of the shackle on the end of the rope is passed. The screws are then taken out of the guide, and it is lowered to the plat below. The new guide is then pulled up by means of the rope and put in place, after which the stages are shifted up, and so the work proceeds. Operating in this way, experienced men can get over a considerable length of shaft in a very short time.

In some mines a good deal of minor shaft repair work is carried out from what is known as a timbering gig, which is a skeleton cage that is hung below the ordinary cage. Light guides can be put in from it, but in handling heavy timber the staging method is to be preferred.

REPAIRING SHAFT-SETS.

The next most common cause of trouble in a shaft is the thrusting in and breaking of wall-plates. If the shaft is boxed, and only a plate here and there is out of alignment, it may not be altogether necessary to replace them at once. As a rule, it is the side-plate that is squeezed in or broken, and to remove it a number of centres or dividers between each compartment have to be taken out, and thus more work is entailed than is usually justified. The thrusting in of the timber is caused by pressure from the walls, but occasionally is the result of improper packing of the set, and it may meet all immediate requirements

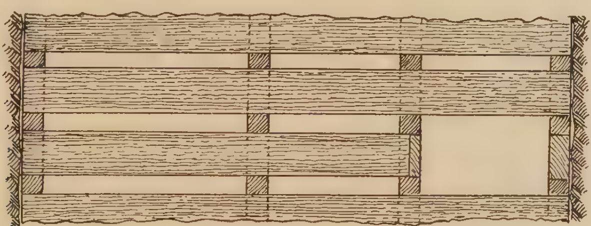


FIG. 320.—Effecting temporary repairs to wall-plates in boxed shaft.

if the ground behind the plate is eased away by drawing it through the spacing, then forcing the plate back into place by using a small machine screw-bar. Another way of effecting a temporary repair under similar circumstances that is sometimes adopted is to cut off the broken part of the plate in a place corresponding with the centre of a divider as in fig. 320, then remove the swelling ground that has caused the trouble, and replace with a new piece of timber of similar length to that removed. When the side pressure is not serious this method will serve its purpose well until such time as more general and thorough repairs are necessary. The dividers that have been taken out in doing the work may be readily put back by spreading the sets a little with the screwjack.

It sometimes happens that a number of consecutive box-sets will be found to have been forced out of alignment, without at the same time any serious damage being done to the timber. In such cases the whole of the shifted sets have to be put back into correct position, and, undoubtedly, the best plan to

follow, from the points of view of economy and convenience, is to start at the lowest point and work upwards. Beginning at this point, at least three complete sets should be entirely removed, even though the timbers are sufficiently sound for further use. The timbermen then proceed by simply dropping the remaining sets one by one, cutting away as much ground as may be necessary, and putting them back in proper alignment on top of the undisturbed sets. The opening that has been provided by the removal of the first three sets enables the replaced sets to be effectively wedged and packed. Any of the timber that is found to be actually decayed or fractured is rejected, but all the rest is used. Work of this kind can be done to a great extent from the cages in the haulage compartments and from temporary stages in the ladderway, and with a little experience the men can make rapid progress at it.

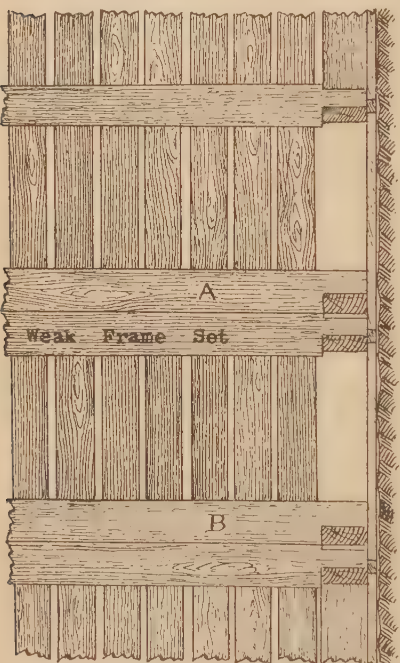


Fig. 321.—Reinforcing damaged sets in frame-set shaft.

The replacing or repairing of frame-sets is attended with somewhat more difficulty. If a set is only strained, but not seriously damaged, and it is merely a matter of getting it back in proper position, no great trouble need be experienced. Sufficient of the lagging should be taken out to enable the ground outside the timber to be eased away, and a jackscrew employed to force the plate out into alignment. If a plate has to be removed altogether, it is different. When such heavy timbers as are used in frame-setting are broken, it is a sure indication that serious pressure is being exerted by the walls. This means that outside the lagging the ground is weak, and as the lagging of two sets has to be taken out before the plate itself can be shifted a considerable area of the bad ground has to be exposed, with great danger of runs occurring. By taking out each piece of lagging separately, easing the ground behind it, and subsequently putting it back and securing it by a *tom*, it is possible to carry out the replacement work safely, but great care is necessary in the whole operation. A simpler and safer way of proceeding is to ease the lagging back on the side of the damaged plate, then put in an entire new set as at A (fig. 321).

A further new set may then be placed, as at B, on top of the set below the damaged one. When the lagging behind this has been eased back and raised up so that its upper ends come behind the new upper set, the old frame can be pulled out. In carrying out this work the posts and studdles of the two sets have to be removed. These can be replaced after the damaged set has been taken away. In a case when further heavy pressure is to be anticipated, the practice is sometimes followed of filling up the whole spaces between a number of frames with new sets laid skin to skin. This unquestionably gives great strength to a shaft where it is only too likely to need it. At times, instead of filling the spaces with full frame-sets, box-sets of somewhat lighter timber are

put in, as in fig. 322. If a close watch is kept for early signs of undue pressure, and light sets of this last-mentioned description are put in, the necessity of removing badly broken frames might be reduced to a minimum by the new sets taking up part of the weight, and thus relieving the old timber. Too

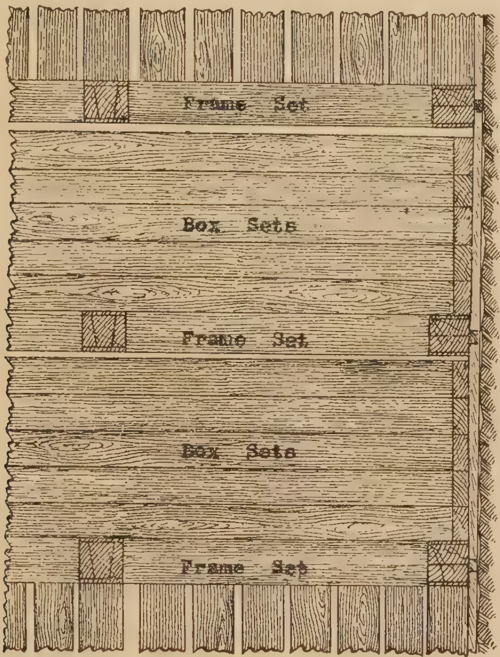


FIG. 322.—Reinforcing damaged sets in frame-set shaft.

great stress cannot, therefore, be laid on the necessity for the men in going through the shaft to keep a keen look-out for signs of pressure on the frames, as attention given at the right time may easily avert much subsequent costly repair work.

MAINTENANCE OF LEVEL TIMBERS.

The keeping of level timbers in good order is a big item in the working costs in nearly all mines, and sometimes necessitates an outlay that seriously affects their financial success. In one mine known to the writer, in which a small vein of only about 20 inches average width is worked, every level-set has to be renewed twice before the stoping of the 150-foot lift is completed. In this case, which is exceptional, the unusual amount of renewal necessary was largely due to only a very inferior class of timber being available, but in practically all mines an immense amount of renewal and repairing of level-sets is called for. Decay of the timber plays some part in causing the trouble, but breakages of legs or caps, due to heavy pressures, are the main cause. Legs are often forced in also without being broken, owing to the joggles in the cap giving way, or a soft floor preventing a good foothold for them being obtained. Whatever may be the cause, the result is the same—unless the

legs are replaced or put back in alignment, the level soon comes together to such an extent as to cause serious interference with mining operations.

As far as breakages of the legs are concerned, much of the trouble resulting from this could be averted if only greater care were exercised in mines in watching for early indications of undue pressure and at once relieving the timber of excessive weight by digging away the swelling ground. In some mines particular care is taken to see that this is done, but in only too many the attention given in this direction is of a most casual nature. Consideration of the large outlay entailed in keeping gangs of men at the work leads to it being neglected, but the outlay would, in many cases, be much more than compensated for by the saving in timber it would effect in the long run.

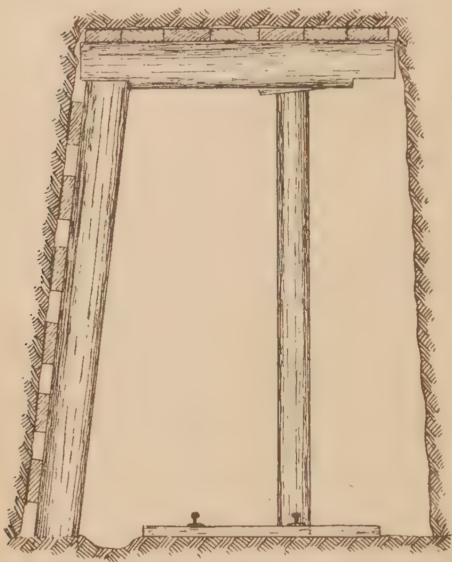


Fig. 323.—Replacing broken leg of level-set.

In the carrying out of the actual repairs or renewals, a number of different methods of procedure are followed. If the set has not sunk seriously, and it is only a matter of setting back or renewing a leg here and there, the common practice is first to catch up the cap of the set by means of a prop, as in fig. 323. Instead of the prop, a machine bar is sometimes employed, especially if the

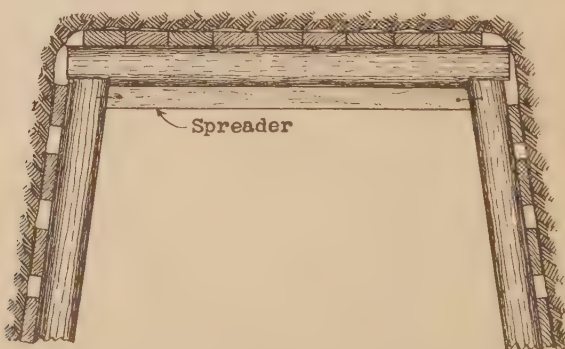


Fig. 324.—Use of spreader in level-sets.

cap has sunk, as by screwing up the bar the cap can be often lifted back to its proper height. Once the cap is caught up in this way, the laths outside the broken or displaced leg can be pulled out, and the leg itself easily removed and either stood in its proper position or replaced by a new one.

If the giving way of the joggles in the cap has led to the leg being forced into the drive, it may not be necessary to put in a fresh cap. A stout spreader driven in between the legs and secured by drift-nailing, as in fig. 324, will

prevent a repetition of the occurrence. If the timber used is not of good quality, it is a wise plan to insert these spreaders in the level-sets before the side pressure has a chance to do any damage. Prevention is better than cure at all times, and if the spreaders are put in early they will surely prevent much subsequent squeezing-in of the timber.

If an entire set has to be renewed, the method of procedure adopted varies according to local circumstances. Should no stoping have been done in the

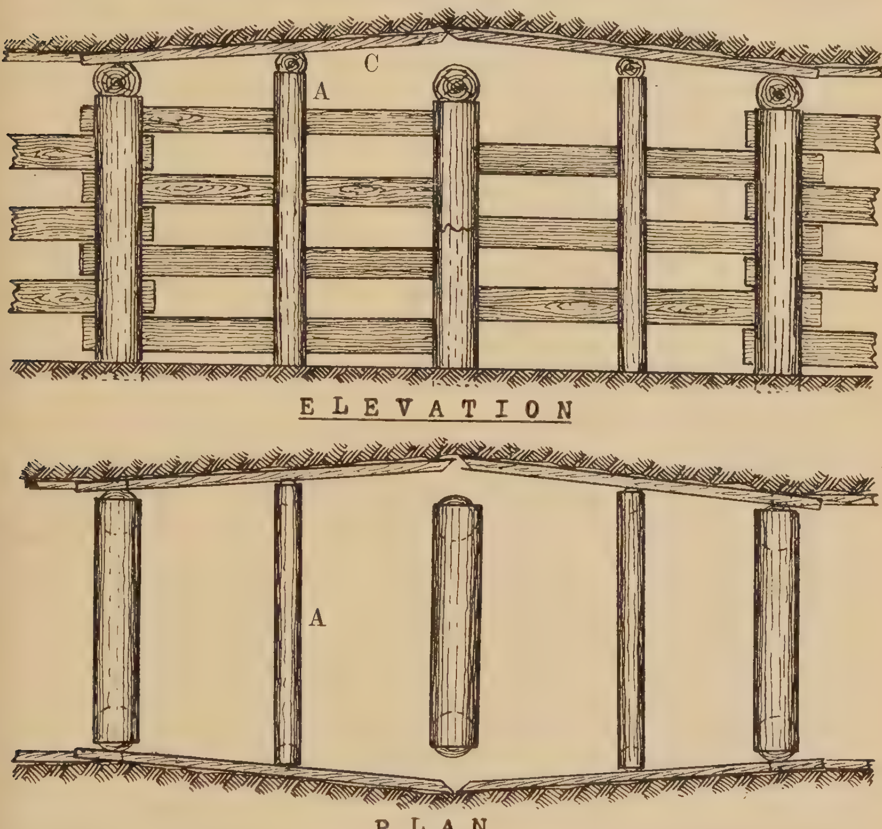


Fig. 325.—Removing and replacing a level-set.

immediate vicinity, and the back is thus fairly strong, all that is necessary is to pull out the old laths, tear down the set, and put up the new one. If the sides of the level are weak, or the back has been worked, the task has to be approached much more carefully. The back is first caught up. This is done by removing the old back laths one by one, and inserting new ones over the cap of the adjacent set on one side of the damaged set. These new laths are driven with an upward slant, as at C (fig. 325). When the whole of the old laths on this side have been replaced by new timber, and the latter has been advanced a little more than half its length, a false-set A is stood, catching up the laths. The latter are then driven nearly home. The back on the other side of the broken set is then picked up in the same manner. If necessary, side laths are entered and advanced simultaneously with those over the back, and

in this way the whole of the surrounding ground is secured. The broken set is then pulled out, and the new set put in, after which the false-sets are removed, allowing the laths to close in on the new set. The whole of the timber is then blocked and wedged in the usual way.

The foregoing method is only applicable to cases where merely an odd set here or there has to be replaced. If a run of crushed sets has to be renewed, the work is carried out somewhat differently, the picking-up of back and sides being usually only done in a forward direction. Starting with a sound set, say as at A (fig. 326), back and side laths are entered, and driven over its cap and outside the legs on either side. When these have been advanced suffi-

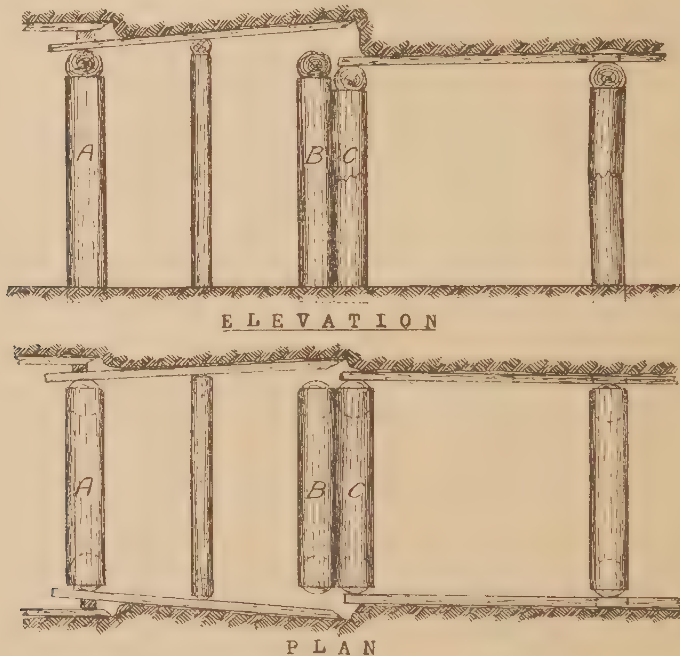


FIG. 326.—Removing and replacing a level-set

ciently, a false-set is stood to catch them and they are then driven home. A new set is now stood alongside the first broken set, as at B. Over the back and outside the legs of this new set, bridges are placed. The false-set is then removed, when the new laths will close in on the bridges, where they are blocked and wedged. Using the new set for tailing purposes, laths are entered in the openings provided at the sides and back by the bridges, as in fig. 327, and these are advanced in the same way as those of the first set. They are caught up by a false set, and the first broken set is then removed. When the laths have been driven home, another new set is stood beside the second broken set of the run. This new set in turn is bridged, and so the work goes on. When the operation is carried out in this way, the men are working under sound timber practically all the time, and are thus less likely to meet with injury from anything falling from the back. Work is usually started from the end nearest the shaft, so that should a serious run from the back take place the men will not be shut in behind it.

It frequently happens that owing to a soft floor the level-sets are squeezed down to such an extent as to make trucking a most uncomfortable operation. In such cases, the level has to be retimbered, and when this is done the timber must be stood at the original height. In the Central Mine, Broken Hill, New South Wales, creep movement caused the whole ore-body near one of the boundaries to sink gradually as extraction progressed. All the level workings within it naturally went down with it, many of the crosscuts subsiding regularly 3 inches to 4 inches, or even more, per month, with the result that in a

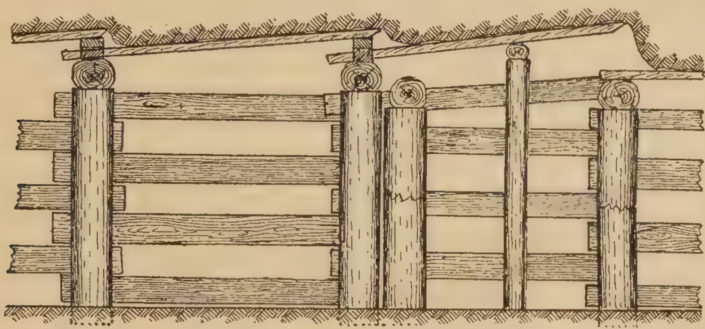


FIG. 327.—Retimbering a level.

comparatively short time the backs were down to about half their original height. This subsidence made trucking difficult, and air-hoists had to be used to pull the loaded trucks up to the roadways in the undisturbed foot-wall crosscuts. It was impossible to raise the sets frequently enough to keep pace with the downward movement, so the practice was to let the sinking proceed till the workings had gone down half their height, then start a new crosscut immediately over the one that had subsided. The new timbers were stood between the sets of the old crosscut and built up on mullock that was filled in ahead of the work to the normal height of the level. Ordinary four-piece sets were used, with spreaders at top and bottom between the legs, and with a view to securing as long life as possible for the new crosscut, legs 10 feet in length were used, a third spreader being inserted between them at the height of about $6\frac{1}{2}$ feet above the sill to prevent side pressure breaking them prematurely. As the new crosscut in turn subsided, this spreader was removed. In advancing the new crosscut through the crushed material, the fore-poling method had to be resorted to.

CHAPTER XVI.

PRESERVATION OF MINE TIMBERS.

In the many experiments carried out during recent years for the treating of timbers used in mines with a view to securing longer life for them, two ends have been chiefly aimed at, one of which was to increase their resistance to early decay and the other to render them less liable to destruction by fire. An immense quantity of valuable timber is destroyed annually in mines as the result of underground fires, consequently the introduction of an economical and effective method of treatment that would prevent them burning readily would enable mine-owners to effect important savings. The amount destroyed in this way is, however, negligible compared with that ruined by over-rapid decay, the monetary loss suffered by mining ventures owing to this being enormous. Throughout a great part of the mining world the average life of untreated timber used underground may be put down as about three years; in some districts it is not much more than as many months. The decay is the result of the attack of certain varieties of fungi on the cell wall, their action being accelerated under conditions of warmth, dampness, and poor ventilation; but a certain amount of it is caused by moisture under warm conditions dissolving out the cells in the sapwood. There are timbers, such as the beech, *Fagus fusca*, which is used so largely in the mines of the West Coast of New Zealand, whose life is prolonged by being kept continually wet, and others that last longest under perfectly dry conditions, but in mines neither of these conditions rules to any great extent. What usually happens is that the timber is exposed to alternating periods of wetness and dryness, and if, in addition to these changes, the ventilation is bad, there are very few classes of timber that will long remain of any use.

Various Chemicals Tested for Efficiency as Timber Preservatives.—There can be little doubt that if all timber were thoroughly seasoned before being sent underground, and perfect ventilation subsequently maintained, the process of decay would be greatly arrested, but it is rarely possible to take these precautions, so efforts have had to be made to effect the desired purpose in other ways, hence the experiments to which reference has been made. In practically all of these the object aimed at has been to force into the timber, or cause it to absorb, some foreign element possessed of toxic qualities destructive to the spores of the fungi, and, to some extent, to make the timber waterproof and fire-resistant. In the experiments, many chemicals, or chemical compounds, have been tried, amongst which may be mentioned sodium fluoride, zinc chloride, zinc sulphate, copper sulphate, carbolineum Avenarius, borax, jodelite, solignum, iron sulphate, coal-tar creosote, water-gas, coal-tar, mercury bichloride, zinc tannin (zinc chloride with a small addition of glue), Wolman salts, melted paraffin with silica in suspension and a small percentage of naphthalene, and brine (with or without chloride of magnesium).

Methods of Applying Timber Preservatives.—The methods of applying treatment have been varied, but have been chiefly along the following four general lines :—

1. Simply steeping the timber in a solution and allowing it to absorb what it could of it.
2. Forcing a solution into the timber under pressure.
3. Painting a solution on the timber.
4. Using a vacuum process in which the timber is first treated with steam, after which the vapours are exhausted, and the solution applied with or without pressure.

Creosote as a Timber Preservative.—As the available records dealing with the tests are somewhat scanty, there seems scarcely sufficient evidence at hand from which to determine with any degree of certainty which preservative, or which particular method of applying it, gives the best all-round results, but some very satisfactory results have undoubtedly been obtained in several directions. It is probable, and, indeed, practically certain, that no one preservative or treatment process can prove universally satisfactory, if for no other reasons than that a chemical which at one place may be procurable at low cost may in another be prohibitively priced, and that a treatment which suits one class of timber may not act well with another.

From the point of view of toxicity to fungus spores, creosote has beyond all doubt been proved to be a preservative of great value, but its high cost prevents its use in many mining countries, and it has the serious disadvantage that it increases the inflammability of any timber to which it is applied. In the treatment with it, the vacuum process, without pressure, is, according to Peele (24), p. 2247, that generally used, the timber being first placed in a cylinder in which the sap is vaporised by steam. This part of the operation is said to take from half an hour to several hours, after which the steam and sap are pumped out of the cylinder, and the latter is filled with creosote at a temperature of about 160° F. Pressure is not used to force the oil into the wood, but a gauge is attached to the cylinder, and when this remains constant, showing that no more oil is being absorbed, the treatment is complete, and the surplus oil is then drawn off. The whole time occupied in treatment is about twenty-four hours, and the amount of oil required varies with kind of wood and degree of seasoning from 5 to 12 or more lb. per cubic foot. The cost is given (1918, U.S.A.) at from 10 to 20 cents per cubic foot.

Zinc Chloride as a Timber Preservative.—Zinc chloride is another preservative the use of which has given good results. It is applied in much the same way as creosote, but in some cases pressure has been used after the steaming to force the solution into the wood. About $\frac{1}{4}$ lb. of the chemical per cubic foot is required. During the years 1906 08, according to the *Mining and Scientific Press* of 25th March 1921, the Philadelphia and Reading Iron Company conducted experiments to determine the relative values of creosote, gas-tar oil, and zinc chloride, using the simple steeping process, and seasoning the timber beforehand for from sixty to ninety days. The experiments proved so satisfactory that a small pressure plant was installed at the Company's Silver Creek Colliery, with which it was found possible to treat the timber with greater economy. For a start, the experiments were made with creosote and gas-tar oil, and good results were obtained, but because of the possibility of fire underground their use was abandoned, as it was considered it would increase the risk to danger-point. Zinc chloride was then tried, half a pound of the salt in a 4 per cent. solution being forced into the timber, per cubic foot, and this method was found so satisfactory that it continued till 1915,

when it became difficult to purchase a sufficient supply at a reasonable cost. During 1907 and 1908 several hundred sets treated with creosote were placed underground, and are said to have shown an increased life of ten years. The sets treated with gas-tar oil showed resistance to decay, but the results were not so good as those from the creosote treatment. Timber treated with the zinc chloride was still in serviceable condition after ten years.

Experiments with Zinc Sulphate.—The use of zinc sulphate as a preservative has been the subject of much experiment in South Africa. Owing to its high cost there, creosote could not be taken into consideration, and, apart from that, the objection of inflammability told against its use. In lieu of some other cheaply procured and effective preservative, it was decided to test the suitability for the purpose of the zinc sulphate solution arising from the process of refining cyanide bullion. This waste liquor was available in considerable quantity. With a view to testing its toxicity to timber-destroying fungi, two of the companies belonging to the Central Mining-Rand group, namely the Rose Deep and the Consolidated Main Reef, laid down experimental plants, with results that are described by Hingle (62) practically as follows: In the first plan, the steeping or open-tank, non-pressure method was adopted. Early in 1919 the tests were begun at the Rose Deep Mine, and a little later at the Main Reef Mine. At the former the timber was treated in a vat 16 feet long, 4 feet wide, and 4 feet deep, a solution containing about 9 per cent. zinc sulphate being used. The timber consisted of lagging poles 4 inches diameter, and props 8 inches diameter, all well seasoned. A certain number of poles and props were set aside untreated to be used as controls underground simultaneously with the treated material. For some hours the solution was heated by means of steam, and was then allowed to cool, the total time of treatment being thirty-six hours. The timbers were then removed from the vat and allowed to dry. In June 1919 they were placed in the mine close to the untreated controls in certain parts of No. 2 level, No. 4 shaft, and on the Engine Plane, where untreated timber was known to decay rapidly. In September 1921 the timbers were examined, when it was found that on No. 2 level the treated timbers were still hard and in good preservation, while, on the other hand, the untreated control timbers which had been subjected to exactly the same atmospheric conditions crumbled away on being touched with a pick, and had obviously been of no practical use for some period previously. On the Engine Plane all the treated props and lagging were found to be in good preservation, while untreated timber that had been placed in the same working a year later than that treated was in poor condition.

At the Consolidated Main Reef a solution containing $2\frac{1}{2}$ per cent. zinc sulphate and $2\frac{1}{2}$ per cent. sodium chloride was used on a similar class of timber, half of the selected material being set aside untreated to be used as controls. The treatment was carried out in two old boiler shells, 16 feet long and 3 feet diameter, from which some of the top plates had been removed. In one of them, used as a hot bath, a steam coil was provided. The initial treatment consisted of keeping the solution in which the timbers were immersed at boiling-point for seven hours, after which the timber was removed to the cold bath in the other boiler shell, and left there for twelve hours. The poles were then taken out, dried off, and sent underground where they were built into pigstyes on various levels, a lead tag being affixed to each pigsty showing the date on which it was constructed. Side by side with each was built a similar pigsty of the untreated timber. The first sets of pigstyes were put in in January 1920, and the last in August of the same year. Until the middle of 1921 there was no marked difference between the treated and untreated timber,

but a few months later the difference had become very noticeable. The untreated timber was obviously rotting rapidly, while in every case the treated was in much better condition. In September 1921 the appearance of the pigstyes built of untreated timber indicated that within a few months they would have rotted completely. In the light of the Rose Deep results, it was considered that the addition of sodium chloride in this case served no useful purpose.

In 1922 the Ferreira Deep Mine began experiments with the same preservative, using a high-pressure treatment. The solution averaged $3\frac{1}{2}$ to 4 per cent. zinc. Poles of *Eucalyptus maidenii* and *Acacia mollissima,* 8 feet long by 4 inches top diameter were selected, and the method of treatment and subsequent results, as recorded by Eckbo (63) were as follows : The treatment plant consisted of two pressure cylinders 36 feet long and 15 inches diameter, capable of holding 25 poles each. The cylinders were fitted with pressure gauges, steam-heating coils, thermometric gauges, and the necessary valves. The preservative was forced into the cylinders by a pump operated by compressed air. The poles forming each charge were marked, weighed, and measured, and after treatment reweighed to determine the exact amount of zinc sulphate absorbed. Except in one case, the solution was used cold, and pressures applied of from 130 lb. to 150 lb. per square inch. The cost of the treatment, exclusive of that of the zinc sulphate and interest on the investment, was calculated to be $1\frac{1}{2}$d. per cubic foot of timber, and it was considered that treatment on a large scale would cost less.

The timbers were subjected to treatment for varied periods with a view to determining the time required to give the best results, but it was found that the amount of solution absorbed and the depth of penetration was very little more after three hours than after one hour. From this it was deduced that one hour's treatment was sufficient, and that the time might even be reduced below this.

After treatment, the poles, together with the untreated controls, were placed underground on stations 4 and 5 of No. 1 shaft in August 1922, and stacked square, with four poles in each layer, but not subjected to any mechanical stress. Examinations were made from time to time, the last recorded one being in August 1925, three years after the experiment was started. The treated poles on each station were then found as sound as when sent underground, while the untreated controls were rotting so fast that in a short time all trace of them would be lost.

The experiments were considered so satisfactory that the management at once proceeded with the erection of a new treatment plant, and is now preserving all timber used in the mine.

The Marr Process.—What is known as the Marr Timber Preserving Process was introduced by R. A. Marr of Richmond, Virginia, U.S.A. It has been described in the *Engineering News* of 12th November 1912. The preservative consisted of a mixture of melted paraffin with silica in suspension and a small percentage of naphthalene. The silica used was a diatomaceous earth of which 92 per cent. would pass 200 meshes to the linear inch. The naphthalene was supposed to cause expansion of the pores and cells of the wood, and to get up an active circulation, expelling the moisture and sap from the pores and drawing in the preservative mixture. The mixture, on cooling, is said to form a solid coating over all the interior cells and pores. It is claimed that it does not leach out, is impervious to water and all organic acids, and being antiseptic prevents the entrance of timber-destroying spores. In a maximum time of four hours the preservative is said to permeate wood to the centre. The

process is an open-tank one, the experimental tank being a small vertical cylinder jacketed to retain the heat furnished by a gasoline burner placed beneath it. For complete impregnation of such timbers as oak and pine, 1·65 to 2 lb. solution per cubic foot is required, of which the cost is set down as about 3 cents per lb., and unseasoned timber is said to respond to the treatment as readily as seasoned.

Wolman Salts.—A preservative that has come into favour in Europe is that known as Wolman salts, the invention of a German chemist, K. H. Wolman. This came into fairly general use, particularly in Germany, between 1902 and 1908, a period during which it is claimed creosote was at its lowest price in the history of timber preservation, and after its introduction is said to have rapidly displaced all other preservatives, including creosote, zinc chloride, and sodium fluoride. Kreer (68) makes the following interesting comments regarding it: The salts, which consist essentially of fluoride and di-nitrophenols or cresols, are admittedly of great toxicity, probably many times that of any treatment hitherto known, and certainly quite equal to the toxicity of creosote. These water-borne solutions are much more easily absorbed and diffused throughout the cellular structure of sapwood than are oil-borne toxins. The mordants contained in the Wolman salt mixtures bring about a fixation in the fibres similar to that of mordants in the preparation of fast dyes, so that there is no leaching out of the salts. They are themselves just soluble enough to make up hot solutions for treatment, but are non-hygroscopic and non-deliquescent, and cause a cementation of fibre in wood that actually demonstrates increased tensile and compressive strength after treatment. Timber, treated with the preservative, that has been in use for from ten to fifteen years in exceptionally bad spots in mines, has been found on examination to have its salt content still present, and the wood fibres in perfect condition. That di-nitrophenols and di-nitrocresols are of themselves inhibitively toxic in solutions as low as one part in 10,000 is well established, and the toxic properties of sodium fluoride are equally well known. It may, however, be worth mentioning that while sodium fluoride in, say, a 0·6 per cent. solution is inhibitive to *Merulius*, *Polyporus*, and *Coniophora*, it is by no means so effective against *Penicillium*, and still less so for the *lenzites* group; whereas phenols and cresols in minute quantities are a complete protection against the latter.

The same writer further points out that timber treated with these salts is rendered largely fireproof. It is not claimed that such timber will not burn, but that its burning is greatly retarded, flame only charring the surface of the timber to a greater or less extent according to duration of the blast, no smoke being formed, no noxious gases given off, and no blaze resulting.

The impregnating solution is made up in the proportion of 1·8 lb. to 100 lb. of water. The amount used varies with different kinds of timber, ranging from 20 per cent. volumetric to 40 per cent., and may be figured for ordinary cases at 12 lb. solution per cubic foot. The cost of the solution is put down at about 3d. per cubic foot.

The A. Riebeck Montan Works, Halle on the Saale, Germany, are said to use in their extensive mining operations about 500,000 lb. of the salts yearly, and other European concerns such as the Rutgerswerke Aktiengesellschaft, Berlin-Charlottenburg, and Johannes Koyemann & Co., Hamburg, have had much experience with them. The salts are now being used in the pressure treatment process in various parts of the United States of America, but the use of the preservative in that country is still too recent for results to be obtainable.

Burnetising Process.—With regard to zinc chloride, although its toxic

value as a wood preservative is now generally admitted, the difficulty of securing it at a reasonable price is against its general use, and it has the further defect that it leaches out of the timber readily and is thus unsuitable for use in wet places. By way of overcoming this defect, what is known as Burnetising has been tried. This consists of adding a small proportion of glue to the mixture. The cost of the chemical is likely, however, to continue to militate against its use to any important extent.

Sodium Fluoride.—Concerning sodium fluoride, it seems that great difficulty has been experienced in getting it of sufficient purity to give the best results. It is considered that it should contain at least 94 per cent. sodium fluoride, whereas the average grade on the market only contains about 78 per cent.

Conditions Governing Use of Timber Preservatives.—From the foregoing the conclusion can be safely drawn that certain preservatives, such as creosote, zinc chloride, zinc sulphate, and Wolman salts, have been proved beyond doubt to be effective in preventing the attack of fungus spores and prolonging the life of mine timber, and that the most approved method of treatment is to force the solution into the wood by pressure in the presence of heat. It is clear also that, all things else being equal, the effective preserving of the timber must result in economy of mining costs ; if the life of the timber can be doubled or trebled, it can scarcely fail to do so. The fact remains, however, that whatever preservative is used, the chemical forming its base must be procurable at a reasonable price. In South Africa, the zinc sulphate being otherwise a waste product, its use for the purpose may well be justifiable and profitable under circumstances where that of any other known preservative would not be. Further, the timber must be of a kind amenable to treatment. In South Africa the tests made with *Eucalyptus maidenii* and *Acacia mollissima* (black wattle) were satisfactory, but, according to Bell (64), not nearly such good results were obtained in treating pitch pine or Cape pine, the absorption in these timbers being low. This was due, it was thought, to the presence of resinous bodies in the timber. Many experiments were made in the way of giving the timbers a preliminary treatment with such solvents as alcohol, benzene, petrol, and acetone with a view to overcoming the defect, but the results obtained showed little improvement. The point is that the adoption of any particular preservative in any mining district must be determined by local conditions, and despite any results obtained elsewhere, it behoves a mine manager thinking of introducing a preservative process on a field where such work has not previously been attempted, to make careful experiment for himself before going in for any large plant.

BIBLIOGRAPHY.

ABBREVIATIONS.

M. & M.	*Mines and Minerals.*
M. & S.P.	*Mining and Scientific Press.*
E. & M.J.	*Engineering and Mining Journal.*
Proc. A.I.M.E.	*Proceedings Australian Institute of Mining Engineers* (now Australian Institute of Mining and Metallurgy).
Trans. A.I.M.E.	*Transactions American Institute of Mining Engineers* (now American Institute of Mining and Metallurgy).

1. **Cleland, E. D.,** *West Australian Mining Practice.*
2. **Parsons, A. B.,** "Mining Methods at Butte and Superior," *M. & S.P.*, vol. cxxi. p. 514.
3. **Foster, C. Le Neve,** and **Brough, B. H.,** *Ore and Stone Mining.*
4. **Fairweather, A.,** "Cylindrical Wooden Ore Passes," *Proc. A.I.M.E.*, No. 12 (new series).
5. **Ihlseng, M. C.,** *A Manual of Mining.*
6. **Rice, C. T.,** "Combination Post and Set Timbering," *E. & M.J.*, vol. xciii. p. 302.
7. **Warren, P. H.,** "Mining on Narrow Lodes," *Proc. A.I.M.E.*, No. 8 (new series).
8. **Weyland, R. G.,** "Homestake Mine Construction," *M. & S.P.*, vol. cxx. p. 540.
9. **Storms, W. H.,** *Methods of Mine Timbering.*
10. **Botsford, H. L.,** "Rogers Shaft at Iron Mountain, Michigan," *E. & M.J.*, vol. xcii. p. 675.
11. **Leggett, T. H.,** "Deep Level Shafts in Witwatersrand," *Trans. A.I.M.E.*, vol. xxx. p. 947.
12. **Storms, W. H.,** *Timbering and Mining.*
13. **Godfrey, J. R.,** "Some Methods of Timbering and Working Wide Lodes in New South Wales," *Proc. A.I.M.E.*, vol. vii.
14. **Davenport, L. D.,** "Square Set Timbers," *E. & M.J.*, vol. xcv. p. 179.
15. **Hebbard, J.,** "Systems of Stoping in Broken Hill Mines," *Barrier Miner*, Dec. 1898.
16. "Timber Dam for Mine Use," *E. & M.J.*, vol. xciii. No. 3, p. 161.
17. **Arentz, S. S.,** "A Standard Ore Chute," *E. & M.J.*, vol. xcii. No. 26, p. 1215.
18. **Barton, B. V.,** "Rill Stoping and Skip Haulage," *Proc. A.I.M.E.*, No. 10 (new series).
19. "Heavy Combination Stope Timbering," *Report of Mining Industry of Idaho*, 1913.
20. **Fairweather, A.,** "Open Stoping on Wide Lodes," *Proc. A.I.M.E.*, No. 10 (new series).
21. "Mesabi Underground Turn Timbering," *E. & M.J.*, vol. xcvii. No. 24, p. 1195.
22. "Method of Driving in Heavy Ground," *Australian Mining Standard*, 1912.
23. **M'Donald, P. R.,** "Mining at the Nevada Consolidated," *M. & S.P.*, June 10, 1916, p. 858.
24. **Peele, Robert,** *Mining Handbook.*
25. **Schloesser, Robert,** "Hexagon Sets," *Proc. A.I.M.E.*, No. 5 (new series).
26. **Sanders, Parlee,** and **M'Donald,** *Mine Timbering.*
27. **Davenport, L. D.,** "Shaft Sinking at Minnesota Iron Mine," *E. & M.J.*, vol. xciv. No. 18, p. 830.
28. **Roberts N. J.,** "Cast Iron Brackets or Chairs for Centre Guide Supports, Kintore Shaft, Broken Hill, N.S.W.," *Proc. A.I.M.E.*, No. 12 (new series).
29. **Donaldson, F.,** *Practical Shaft Sinking.*
30. **Ireland, M.,** "Timbering at Mt. Rex Mines, Ben Lomond, Tasmania," *Proc. A.I.M.E.*, vol. x.
31. **Pamely, C.,** *Coal Mining.*
32. **Donaldson, R. J.,** "Some Features of Mining in the Central Mine, Broken Hill, N.S.W.," *Proc. A.I.M.E.*, No. 10 (new series).
33. **Rice, C. T.,** "Battery Method of Stull Timbering," *E. & M.J.*, vol. xciii. No. 5, p. 255.
34. **Coldham, J. C.,** "Underhand Stoping with Square Sets," *Proc. A.I.M.E.*, No. 10 (new series).

35. **Davenport, L. D.,** "Emergency Ore Gate," *E. & M.J.*, vol. xciv. No. 20, p. 930.
36. **Macer, L. W.,** "Hanging Wall Supports on Far East Rand," *M. & S.P.* (reprint), vol. cxx. No. 15, p. 539.
37. **Bridge, J. M.,** "Notes on Steel Ore Passes," *Proc. A.I.M.E.*, No. 10 (new series).
38. **Hodge, W. R.,** "Underswung Rack-operated Chute Gate," *E. & M.J.*, vol. xcvii. No. 24, p. 1193.
39. **Russel, H. Y.,** "The Treasury Tunnel Raise," *E. & M.J.*, vol. xciv. No. 24, p. 1137.
40. "South African Shaft Sinking Practice," *M. & M.*, vol. xxxiii. No. 4 (reprint from *South African Mining Journal*).
41. **Finlayson, J.,** "Long Tunnel Incline and Vertical Shaft, Walhalla, Victoria," *Proc. A.I.M.E.*, vol. xiv. p. 103.
42. **Henderson, C. W.,** "Developing Poverty Gulch Claims, Colorado," *M. & M.*, vol. xxxi. No. 12, p. 727.
43. **Gilmour, J. E.,** and **Johnstone, W. H.,** "Mining Methods in Waihi Mine, New Zealand," *Proc. A.I.M.E.*, vol. xvi. p. 25.
44. **Goodney, S. J.,** "Raising a Shaft in Hard Rock, Armenia Mine," *M. & M.*, vol. xxxii. No. 8, p. 495 (a paper read at the 16th Annual Meeting of The Lake Superior Mining Institute).
45. **Beaumont, E. K.,** "Systems of Stoping and Timbering Employed at Broken Hill, N.S.W.," *Proc. A.I.M.E.*, vol. ix.
46. "Mine Supports in Germany" (translation), *M. & M.*, vol. xxxiii. No. 5, p. 240.
47. **Fairweather, A.,** "Picking up Bottoms after Open Stoping," *Proc. A.I.M.E.*, No. 13, p. 1.
48. **Cory, E. N.,** "Raising Shaft at Rolling Mill Mine," *M. & M.*, vol. xxxiii. No. 5, p. 288 (paper read before Lake Superior Mining Institute, August 1912).
49. **Vale, W. H.,** "Examples of Mine Timbering," *Proc. A.I.M.E.*, No. 2 (new series).
50. **Rickard, T. G.,** "The Bunker Hill Enterprise—Methods of Mining and Timbering," *M. & S.P.*, vol. cxx. No. 10, p. 337.
51. **White, J., White, H. S.,** and **Sewell, L. G.,** "On Underground Mining Methods at Mt. Morgan Mine, Queensland," *Proc. A.I.M.E.*, vol. xv. p. 390.
52. **Conklin, B. M.,** "Mining Dangerous Ground on the Mesabi Range," *Wisconsin Engineer*, April 1912.
53. **Moore, A. J.,** "A Proposed Modification of the Square Set," *Proc. A.I.M.E.*, vol. xvi. p. 224.
54. **Boulton, W. S.,** *Practical Coal Mining*, vol. ii.
55. **Rice, C. T.,** "Shaft Sinking at the Indiana Mine, Michigan," *E. & M.J.*, vol. xcv. No. 10, p. 509.
56. **Campbell, C. St. G.,** "Shaft Sinking, Lake Superior Copper Company, Michigan," *Trans. Canadian Society of Civil Engineers*, vol. xviii. 1903.
57. **M'Donald, P. B.,** "Rolling Mill, No. 2 Shaft, Michigan," *E. & M.J.*, vol. xciii. No. 25, p. 1237.
58. **M'Kay, A. A.,** "Drop Shaft Lining," *Bulletin Canadian Institute of Mining and Metallurgy*, Feb. 1922.
59. "The Ancient River Beds of the Forest Hill District" (Report No. 10, State Mineralogist of California).
60. **Del Mar, A.,** "Gate for Ore Bin Chute," *E. & M.J.*, vol. xciii. No. 15, p. 735.
61. "Treatment of Mine Timbers," *M. & S.P.*, vol. cxxii. No. 10, p. 336.
62. **Hingle, L. D.,** "Preserving Mine Timber," *Journal, South African Institution of Engineers*, March 1922.
63. **Eckbo, N. B.,** "Preserving Mine Timbers with Zinc Sulphate," *South African Journal of Industries*, Nov. 1925.
64. **Bell, H. D.,** "Impregnation of Mine Timbers with Zinc Sulphate for Protection against Attack by Fungi," *Trans. Chemical, Metallurgical and Mining Society of South Africa*, March 1924.
65. **Faulds, A.,** "Construction of Mine Dams," *Trans. Mining Institute of Scotland*, vol. xxvi. Part I.
66. **Kerr, C. L.,** *Practical Coal Mining.*
67. **Nevins, J. Nelson,** "Gate for Skip-loading Bins," *E. & M.J.*, vol. lxxxii. No. 5.
68. "Protecting Mine Timber," *Queensland Govt. Mining Journal*, Feb. 14, 1925 (reprint from *E. & M.J.*).

INDEX OF MINES AND LOCALITIES.

NAME INDEX.

GENERAL INDEX.

PRINTED IN GREAT BRITAIN BY NEILL AND CO., LTD., EDINBURGH.